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assessment report

STATE OF MONTANA
NATURAL RESOURCE DAMAGE PROGRAM

ROCKER GROUNDWATER INJURY ASSESSMENT REPORT
ROCKER, MONTANA

JANUARY 1995

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ROCKER GROUNDWATER INJURY ASSESSMENT REPORT

Prepared for

Department of Justice
Natural Resource Damage Litigation Program
Helena, Montana

Prepared by

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126 Mc Leod Avenue
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William W. Woessner, Ph.D.

January, 1995

I am prepared to testify as to the appropriateness of the statistical methodologies used in the following reports and that the differences between groundwater conditions of the control and assessment areas, in each one of these reports, are statistically different under D.O.I. Regulation, 43 C.F.R. § 1172(h)(5):

1. *Anaconda Groundwater Injury Assessment Report, Deer Lodge Valley, Montana.* By William W. Woessner, Ph.D., January 1995.
2. *Milltown Groundwater Injury Assessment Report.* By William W. Woessner, Ph.D., January 1995.
3. *Rocker Groundwater Injury Assessment Report, Rocker, Montana.* By William W. Woessner, Ph.D., January 1995.
4. *Montana Pole Treatment Plant Ground Water Injury Assessment, Butte, Montana.* By John J. Metesh, Montana Bureau of Mines and Geology, April 1993.

Richard J. Brand 1/10/95

Richard J. Brand, Ph.D.

EXECUTIVE SUMMARY

The Rocker Timber Framing and Treating Plant milled and treated timbers used in the Butte underground mines between 1909 and 1957. As a result of plant operations, the soil and groundwater beneath and in the vicinity of the site are contaminated with arsenic, metals and organic compounds. It is estimated that 191 acft of groundwater exceeds drinking water standards at the site. In addition, annual discharge of this contaminated groundwater through and from the site was approximated at between 4.7 and 5.3 acft. The presence of hazardous substances in the aquifer substrate and the continual natural recharge of the site with water will result in hazardous substance release and groundwater contamination for hundreds of years unless the site is remediated.

TABLE OF CONTENTS

page

EXECUTIVE SUMMARY.....i

LIST OF FIGURES.....iii

LIST OF TABLES.....v

LIST OF APPENDICES.....vi

INTRODUCTION.....1

Site Description.....1

History.....1
Climate.....1
Geology and Hydrology.....5

GROUNDWATER INJURY DETERMINATION.....14

Source.....14

Manner, Pathway and Duration of Release.....18

Relevant Standards.....20

Data Assessment.....20

GROUNDWATER INJURY ASSESSMENT.....20

Baseline Conditions.....24

Extent of Injured Groundwater.....24

Flux of Groundwater.....43

RECOVERABILITY.....43

SUMMARY.....46

REFERENCES CITED.....46

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LIST OF FIGURES

Figure 1: Location map of Rocker, Montana and the vicinity..... 2

Figure 2: Location of the Rocker Timber and Framing Plant (KER, 1992)..... 3

Figure 3: Location of plant facilities (KER, 1992)..... 4

Figure 4: Locations of soil borings and cross sections (ESE, 1994)..... 6

Figure 5: Cross section AA-AA' (ESE, 1994)..... 7

Figure 6: Cross section BB-BB' (ESE, 1994)..... 8

Figure 7: Location of monitoring wells (modified from KER, 1992).....11

Figure 8: Groundwater elevation contours, shallow depth wells (KER, 1992).....12

Figure 9: Groundwater elevation contours, intermediate depth wells (modified from KER, 1992).....13

Figure 10: Hydrographs of shallow well RH-17 and Silver Bow Creek between August and September 1992 (ESE, 1994).....15

Figure 11: Equipotential surface of the consolidated volcanic aquifer shown in dashed lines (ESE, 1994).....16

Figure 12: Surface soil sampling sites. Sites #01 to #090 are located in the area of soil removed in 1989 (KER,1992).....17

Figure 13: Location of one monitoring well (GS-1) and domestic wells (DW) and AYERS, and the Town Pump Well, TP, in the vicinity of Rocker, Montana.....23

Figure 14: Median concentrations of arsenic in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....28

Figure 15: Median concentrations of arsenic in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....29

Figure 16: Median concentrations of cadmium in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....30

Figure 17: Median concentrations of copper in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....31

Figure 18: Median concentrations of zinc in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....32

Figure 19: Median concentrations of manganese in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....33

Figure 20: Median concentrations of manganese in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....34

Figure 21: Median concentrations of iron in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....35

Figure 22: Median concentrations of iron in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....36

Figure 23: Median concentrations of sulfate in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....37

Figure 24: Median concentrations of sulfate in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....38

Figure 25: Median concentrations of PAH's in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....39

Figure 26: Median concentrations of PAH's in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).....40

Figure 27: Median concentrations of one or more constituents in the shallow zone exceed drinking water standards. Cross section A-A' used for flux calculations (base map modified from KER, 1992).....41

Figure 28: Median concentrations of one or more constituents in the intermediate zone exceed drinking water standards. Cross section B-B' used for flux calculations (base map modified from KER, 1992).....42

LIST OF TABLES

TABLE 1: Well Construction and Depth to Water Data (ESE, 1994)..... 9

TABLE 2: Hydraulic Conductivity from Slug Test Data Prepared by KER (1992) and Reinterpreted by ESE (1994).....10

TABLE 3: Statistical Summary of Metals in Soil at Rocker (ESE, 1994).....19

TABLE 4: Primary and Secondary Drinking Water Standards Exceeded at the Rocker Site.....21

TABLE 5: Organic Constituents Exceeding Standards at Rocker..22

TABLE 6: Wells with Samples of Groundwater Considered as Background Water Quality in the Rocker Area.....25

TABLE 7: Median Concentrations of Constituents Listed on Table 3 for Background Groundwater (Table 4).....26

TABLE 8: Estimated Volumes of Contaminated Groundwater.....44

TABLE 9: Annual Discharge of Contaminated Groundwater in the Shallow and Intermediate Zone.....45

LIST OF APPENDICES

Appendix A: Groundwater Quality Data for Parameters Exceeding Drinking Water Standards, Rocker, Montana.....48

Appendix B: Groundwater Quality Data for Parameters Exceeding Drinking Water Standards, Rocker, Montana (adjusted for detection limits).....52

Appendix C: Groundwater Quality Parameters Median Values Rocker, Montana.....57

INTRODUCTION

This report presents an analysis of the character of hazardous substance sources, the mechanisms and pathways by which these substances enter the groundwater system, and the distribution of contaminants in the groundwater in the vicinity of Rocker, Montana (Figure 1).

Site Description

The town of Rocker is located approximately seven miles west of Butte, Montana (Figure 1). Rocker is part of the Rocker Rural Center Zone as zoned by Butte/Silver Bow County. Principal land uses include residential, commercial and agricultural. The majority of the Rocker Site discussed in this report includes the active line of the Rarus Railroad and the site of a timber framing and treatment plant (KER, 1991). The Rocker Timber Framing and Treating Plant was located in the floodplain of Silver Bow Creek to the south of the creek (Figure 2). The southern boundary of the site is bordered by the Rarus Railroad and the community of Frederisksburg (Figure 2) (KER, 1992).

The Rocker site is an Operable Unit of the Silver Bow Creek/Butte Area Superfund Site. Preliminary site characterization has been accomplished by seven different consulting firms (Stiller, 1985; Hydrometrics, 1987 and 1989; CH2M Hill and Chen-Northern, 1989; KER, 1989; PTI, 1991; KER, 1991; KER, 1992; Chester, 1993; ESE, 1994). It is these site characterization documents that have provided the background for this assessment.

History

The Rocker Timber Framing and Treating Plant was owned by the Anaconda Company and it was operated from 1909 to 1957. The plant milled and treated timbers used in mining operation in Butte and the surrounding areas. Timber was preserved by dipping them in a solution containing dissolved arsenic. The plant also occasionally treated timbers and poles for Montana Power Company using creosote dipping and pressure treating techniques (KER, 1992). The plant consisted of a framing mill, boiler house, wood preserving building, carpenter shop, an office, two dip tanks and a preservative storage tank (Figure 3). The mill was destroyed by fire in 1925 and the remaining plant was dismantled in 1957 (KER, 1992).

Climate

Rocker's climate is considered continental and characterized by cold winters and short, cool, summers. Mean annual precipitation and temperature reported at nearby Butte are 11.73 in and 38.9°F, respectively. January is the coldest month, and July and August the warmest months (KER, 1991).

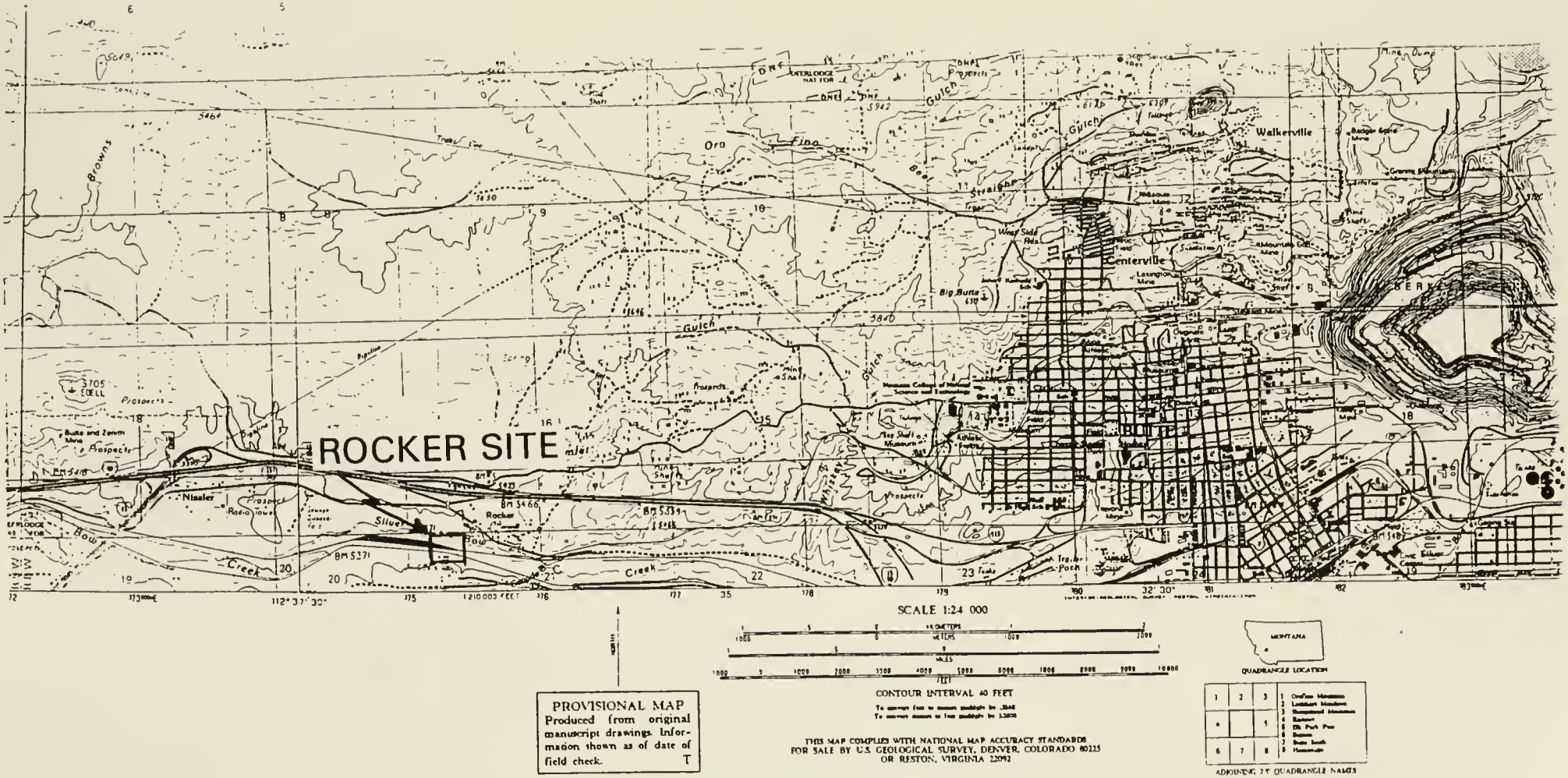

Figure 1: Location map of Rocker, Montana and the vicinity.

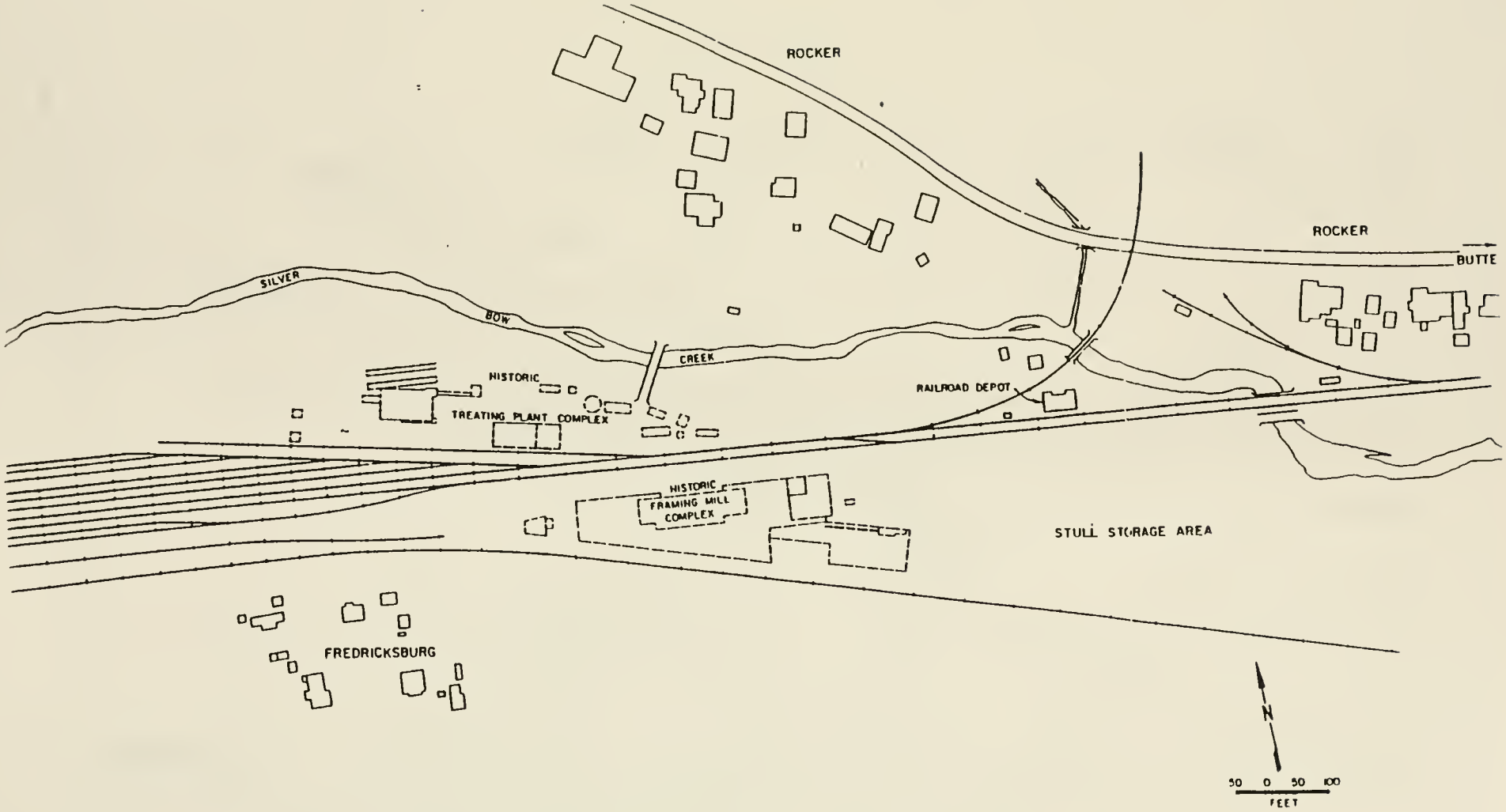

Figure 2: Location of the Rocker Timber and Framing Plant (KER, 1992).

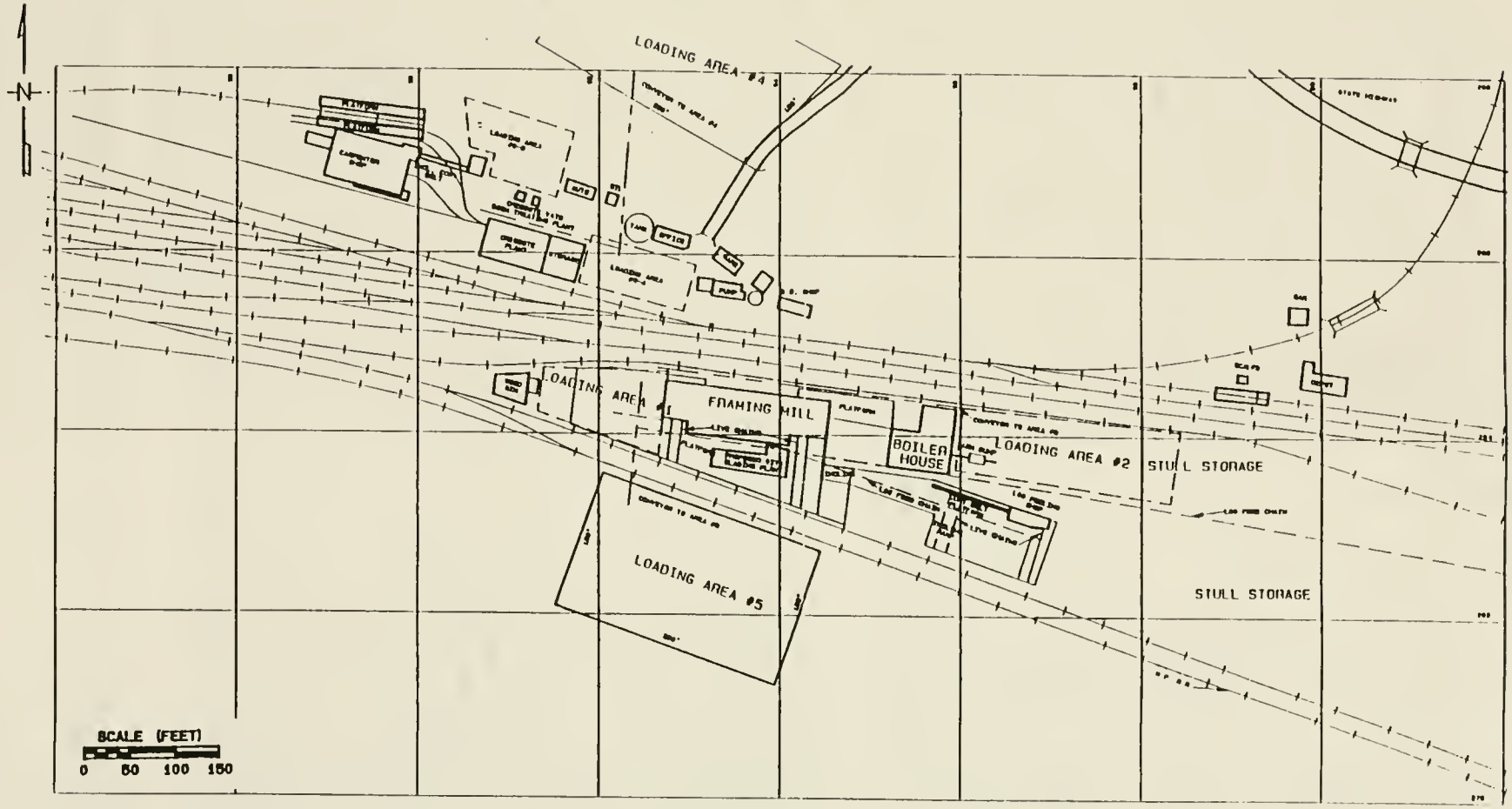

Figure 3: Location of plant facilities (KER, 1992).

Geology and Hydrology

The site is underlain by the Quaternary floodplain deposits of Silver Bow Creek and most likely the valley fill Tertiary sediments. Surficial geology included the near surface unconsolidated deposits composed of unconsolidated alluvium, colluvium and potentially glacial deposits. These deposits are composed of clayey-silt and silty-sand to sandy-gravel size and are water bearing beneath the Rocker site (ESE, 1994). Soil borings (Figure 4) in the immediate vicinity of the site reveal the heterogeneous nature these deposits (Figures 5 and 6). The site valley floor deposits are underlain by weathered tuff/lakebed deposits reported to be composed chiefly of volcanic ash tuffs with lake bed or weathered mudstones (ESE, 1994). ESE (1994) propose a history of the area that includes downcutting which formed an initial paleo-channel composed of sand and gravel in the tuffs; these deposits grade laterally into overbank deposits consisting of clays, silts and sands. The a volcanoclastic aquifer underlies the unconsolidated sediments. The average thickness of the unconsolidated sediments underlying the site ranges from 40 to 80 ft. A upper silty clay zone above the volcanics is stated appears to restrict water communication between the alluvial aquifer and the volcanic aquifer (ESE, 1994). However, sand and gravel are also in direct contact with the underlying consolidated material (Figures 5 and 6).

Groundwater occurs in the unconsolidated material and the water table is commonly less than 10 ft below land surface (Figures 5 and 6, and Table 1). The 60 to 70 ft of saturated material above the volcanic silts appears to be acting as one unconfined groundwater system (KER, 1992). It was originally divided in to a shallow (< 20 ft) and intermediate >20 to 60 to 70 ft) zone for aquifer property and flow determination (KER, 1992). Results of hydraulic conductivity testing at monitoring well locations (Figure 7) are presented in Table 2. Wells classified as shallow and intermediate have about the same average values of hydraulic conductivity, reported as 2 to 5 ft/d by KER (1992) and modified to an average of 9.4 ft/d by ESE (1994). A similar value is used to represent the near surface the underlying weathered volcanics (ESE, 1994). Lab values for well indurated volcanic samples ranged from 0.06 to 0.0002 ft/d (KER, 1992). An aquifer test of a well deriving water from the volcanics at the Town Pump north of the site yielded a transmissivity range of 4,250 to 28,016 ft^2/d. Storativity values ranged from 0.0004 to 0.003 (ESE, 1994; MBMG, 1994). The effective porosity, as determined from geotechnical testing, was stated to be 0.40 for the shallow unconsolidated unit and 0.45 for both the intermediate zone and the underlying volcanic material (KER, 1992). ESE (1994) assumes values range from 20 to 45 percent for the alluvial material as they recognize the presence of sand and sand and gravel.

The groundwater flow direction is to the northwest south of Silver Bow Creek and to the southwest north of the creek (Figure 8

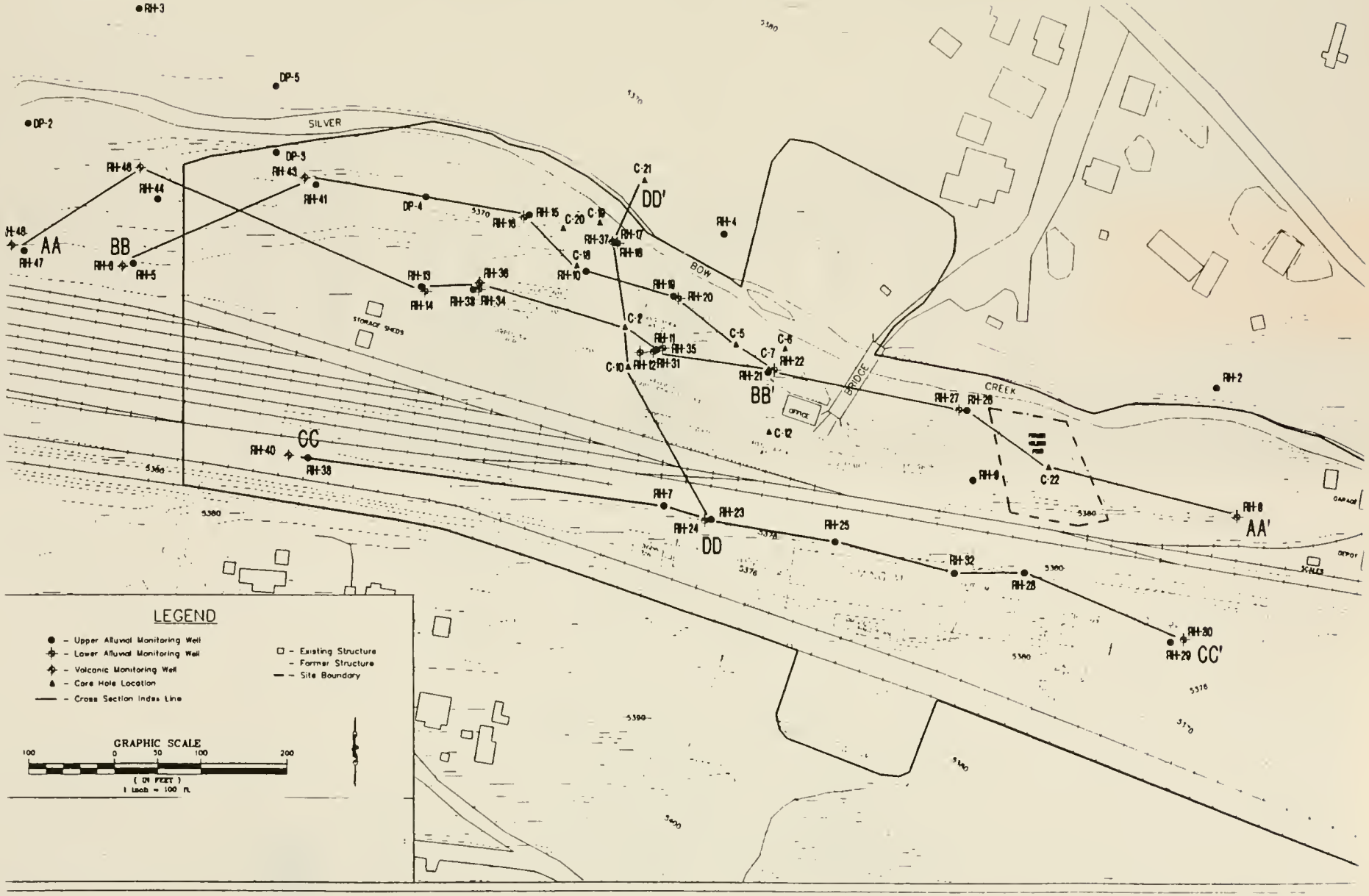

Figure 4: Locations of soil borings and cross sections (ESE, 1994).

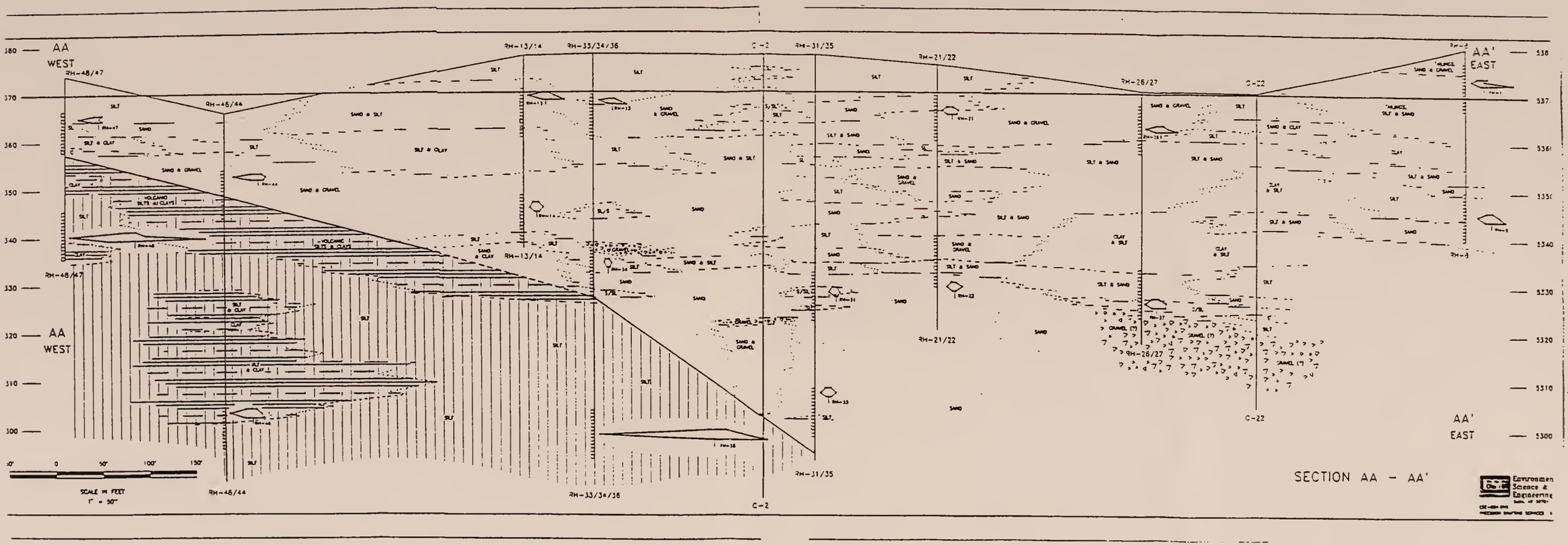

Figure 5: Cross section AA-AA' (ESE, 1994).

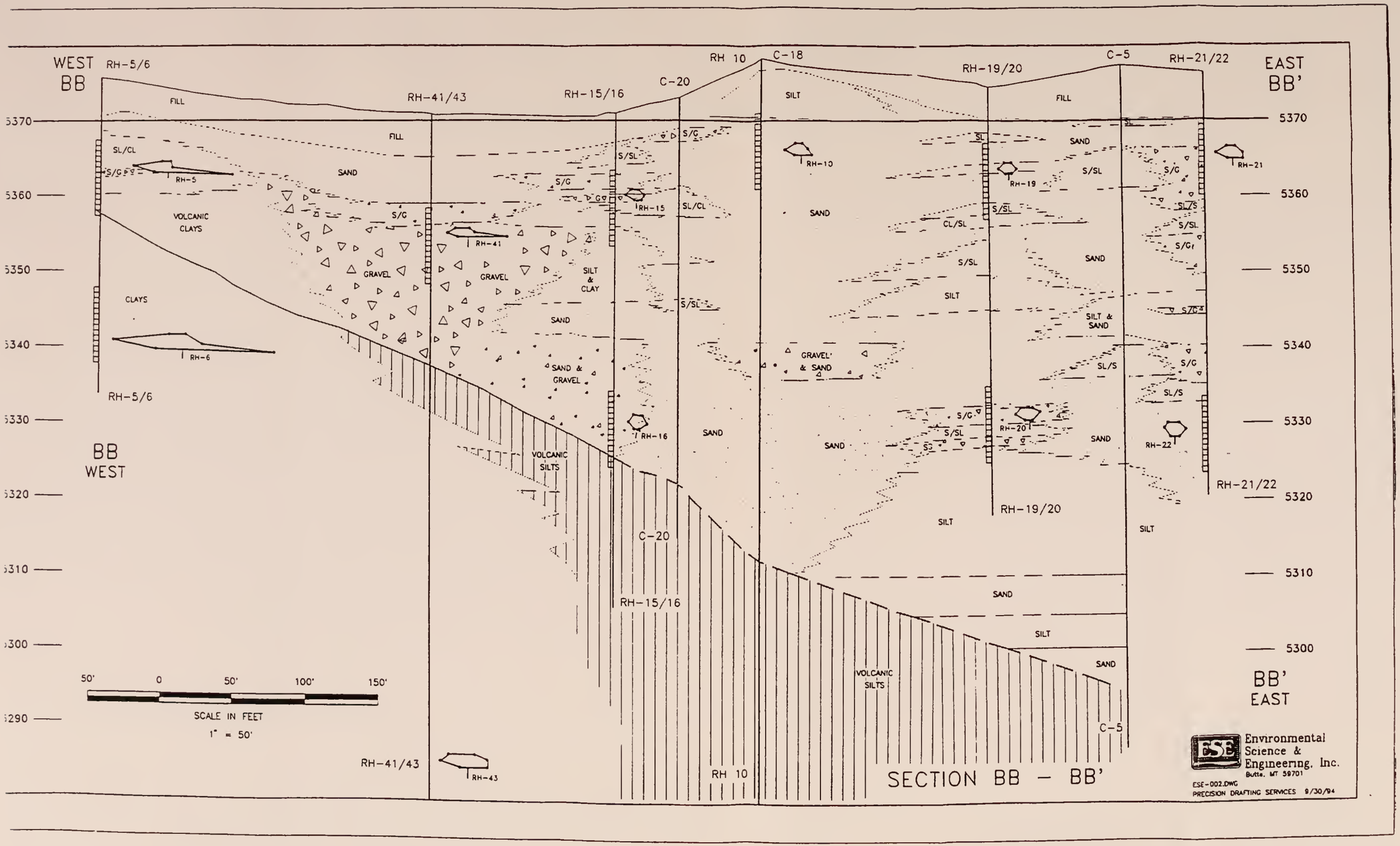

Figure 6: Cross section BB-BB' (ESE, 1994).

TABLE 1: Well Construction and Depth to Water Data (ESE, 1994).

Well No		Approx Well Depth (ft)	Well Diameter (in)	Top of Casing Elev. (ft)	11/5&9/91 (ft)		9/2/92 (ft)		9/22/92 (ft)		9/30/92 (ft)	
					Level	Elev.	Level	Elev	Level	Elev	Level	Elev
Drive Points	DP-1	7 4	1 25	5370 90	NA	NA	5.51	5367.39	NA	NA	NA	NA
	DP 2	8 00	2	5368 80	NA	NA	4 74	5364.06	4 68	5364 12	4 69	5364 11
	DP-3	8 25	2	5368 96	NA	NA	NA	NA	3.58	5365.38	3 55	5365 41
	DP 4	7 44	2	5371 78	NA	NA	NA	NA	NA	NA	5 18	5366 60
	DP-5	8 09	2	5366 10	NA	NA	NA	NA	NA	NA	2.56	5365.54
Shallow Wells	RII 1	15	4	5381 84	10.62	5371.22	9 84	5372 00	9 69	5372 15	9 78	5372 06
	RII-2	15	2	5376 06	4 97	5371 09	4 84	5371 22	4.85	5371 21	4.85	5371 21
	RII 3	15	2	5371 85	7 05	5364 80	7 16	5364.69	6 98	5364 87	6 98	5364 87
	RII-4	15	2	5373 40	5 37	5368 03	5.39	5368.01	5.31	5368 09	5.32	5368 08
	RII 5	20	4	5375.60	11.55	5364 05	11.36	5364 22	11.36	5364.24	11 34	5364 26
	RII-7	20	2	5379.61	10.06	5369.55	10.07	5369.54	9.99	5369 62	10 00	5369 61
	RII-9	16	2	5377 30	9.00	5368.30	9.11	5368.19	8 99	5368 31	8 97	5368 33
	RII 10	17	4	5378 31	10 94	5367.37	10 95	5367.36	10.80	5367.51	10 83	5367 48
	RII-11	17	4	5377 99	9 88	5368.11	9.83	5368 16	9 73	5368 26	9 73	5368 26
	RII 13	19	2	5377.65	10.68	5366 97	10.70	5366 95	10 63	5367 02	10 60	5367 05
	RII-15	18	4	5374 04	6 65	5367 19	6.86	5367.18	6.75	5367.29	6 76	5367.28
	RII-17	14 5	4	5374 69	7 22	5367 47	7.27	5367.42	7.14	5367.55	7.17	5367.52
	RII 19	17.5	4	5377.21	9 53	5367.68	9.54	5367 67	9 40	5367.81	9 43	5367 78
	RII-21	16 5	4	5378 80	9 70	5369.10	9 71	5369.09	9.58	5369.22	9.60	5369 20
	RII 23	18 5	4	5379.69	10.30	5369.39	10.06	5369.63	9.98	5369.71	10 03	5369 66
	RII-25	17.5	4	5381.12	10 35	5370.77	10 40	5320.72	10.32	5370 80	10.33	5370.79
	RII 26	13 5	4	5374 02	3.65	5370.37	3.88	5370 14	3 86	5370 16	3.90	5370 12
	RII-28	16.5	4	5362 05	10.55	5371.50	10.56	5371.49	10 46	5371 59	10 48	5371.57
	RII-29	15	4	5377.79	5.57	5372.22	5.50	5372.29	5.49	5372.30	5.51	5372.28

Well No		Approx Well Depth (ft)	Well Diameter (in)	Top of Casing Elev (ft)	11/5&9/91 (ft)		9/2/92 (ft)		9/22/92 (ft)		9/30/92 (ft)	
					Level	Elev.	Level	Elev	Level	Elev.	Level	Elev
	RII-32	17	4	5380.26	8 89	5371.37	8.93	5371 33	8 84	5371 42	8 85	5371 41
	RII 33	14 5	4	5380 19	12 90	5367.29	12 92	5367 27	12 79	5367 40	12.80	5367.39
	RII-38	22	4	5380.24	NA	NA	15.96	5364.28	15.92	5364.32	15 94	5364.30
	RII-41	22.5	4	5373.63	NA	NA	7 90	5365.73	7.75	5365.88	7.76	5365.87
	RII-44	22	4	5371 49	NA	NA	7.08	5364 41	6.98	5364.51	6 97	5364 52
	RII-47	16	4	5377.25	NA	NA	13.36	5363.89	13.24	5364.01	13.25	5364.00
Intermediate Wells	RII-6	40	4	5375.24	12 44	5362.80	12.31	5362.73	12.40	5362 84	12.41	5362.83
	RII 8	40	4	5381 67	9.60	5372 07	9.58	5372 09	9 49	5372.18	9 52	5372.15
	RII-12	40	4	5377.87	NA	NA	9 93	5367.94	9 81	5368 06	9 83	5368 04
	RII-14	39	2	5377 16	10.57	5366.59	10 54	5366 62	10.45	5366 71	10 46	5366 70
	RII-16	46 7	2	5373 68	6 50	5367 18	6.38	5367.30	6.36	5367.32	6 35	5367.33
	RII-18	47.25	2	5375.10	7 87	5367.23	7 67	5367 43	7 63	5367 47	7.63	5367 47
	RII 20	49 25	2	5376 86	9.22	5367.64	9.23	5367.63	9.13	5367.73	9 10	5367 76
	RII-22	32.25	2	5378 81	10 56	5368.25	10.59	5368.22	10 48	5368.33	10 48	5368.33
	RII-24	51.25	2	5380 16	11 40	5368 76	11 40	5368.76	11.37	5368 79	11 36	5368 80
	RII-27	47 25	2	5374.21	4 12	5370 09	4 10	5370 11	4 06	5370.15	4 10	5370 11
	RII-30	50.25	2	5378 23	6 20	5372.03	6 12	5372 11	6 11	5372.12	6.12	5372.11
	RII-31	55 25	2	5380 83	13.23	5367 60	13 16	5367.67	13.09	5367.74	15.08	5367.75
	RII-34	51 25	2	5381.11	14.21	5366.90	14.10	5367 01	14 02	5367 09	14.03	5367.08
	RII-48	38	2	5377.31	NA	NA	14.44	5362.87	14.38	5362.93	14.40	5362.91
Deep Wells	RII-35	79.5	2	5380.40	12 87	5367.53	12 78	5367.62	12.72	5367.68	12.71	5367 69
	RII 36	84.25	2	5380 64	19 82	5360 82	19.39	5361.25	19 31	5361 33	45.27	5335.37
	RII-37	76.25	2	5375.63	10.11	5365.52	9.72	5365.91	9.65	5365.98	9.72	5365.91

Well No		Approx Well Depth (ft)	Well Diameter (in)	Top of Casing Elev (ft)	11/5&9/91 (ft)		9/2/92 (ft)		9/22/92 (ft)		9/30/92 (ft)	
					Level	Elev.	Level	Elev.	Level	Elev	Level	Elev.
	RII-40	111	2	5380.30	NA	NA	19 01	5361 26	18 97	5361 33	18 98	5361 32
	RII-43	113	2	5373 20	NA	NA	14.05	5361 15	14.01	5361 19	14 02	5361 18
	RII-46	70	2	5369.38	NA	NA	8.31	5361.07	8.29	5361.09	8.28	5361.10

NA = Not Available

TABLE 2: Hydraulic Conductivity from Slug Test Data Prepared by KER (1992) and Reinterpreted by ESE (1994).

Well	Lithology at Screened Zone[a]	Slug In/ Out	November 1991		September 1992		ESE Hydraulic Conductivity Values Obtained From November 1991 Raw Data
			(cm/sec)	(ft/day)	(cm/sec)	(ft/day)	(ft/day)
RH-1	AL-U	Out	1.2×10^{-1}	34.56	NA	NA	NA
RH-4	AL-U	In	4.3×10^{-3}	12.24	NA	NA	8.35
		Out	4.9×10^{-3}	13.82	3.2×10^{-2}	90.72	6.05
RH-6	VOL	In	2.4×10^{-3}	66.24	NA	NA	37.44
		Out	2.6×10^{-2}	74.88	NA	NA	41.76
RH-8	AL-L	Out	NA	NA	2.4×10^{-3}	6.77	NA
RH-9	AL-U	Out	4.6×10^{-3}	13.10	NA	NA	9.07
RH-13	AL-U	Out	5.5×10^{-4}	1.58	NA	NA	0.22
RH-14	AL-L	In	5.3×10^{-4}	1.44	NA	NA	1.22
		Out	4.6×10^{-4}	1.31	NA	NA	1.17
RH-15	AL-U	In	1.6×10^{-3}	4.61	NA	NA	3.74
		Out	6.3×10^{-3}	17.28	2.3×10^{-3}	6.48	14.87
RH-16	AL-L	In	2.1×10^{-3}	6.05	NA	NA	27.36
		Out	2.0×10^{-3}	5.62	NA	NA	15.84
RH-17	AL-U	Out	6.3×10^{-3}	17.28	NA	NA	9.07
RH-18	AL-L	In	2.1×10^{-3}	5.90	NA	NA	2.45
		Out	2.1×10^{-3}	5.90	NA	NA	4.32
RH-19	AL-U	Out	8.5×10^{-3}	24.48	3.3×10^{-3}	9.36	23.04
RH-20	AL-L	In	1.2×10^{-3}	3.31	NA	NA	18.72
		Out	6.7×10^{-4}	1.87	NA	NA	4.75
RH-21	AL-U	Out	8.5×10^{-4}	2.45	NA	NA	8.64
RH-22	AL-L	In	3.6×10^{-3}	10.08	NA	NA	14.40
		Out	4.6×10^{-3}	13.10	4.5×10^{-3}	12.81	41.76
RH-25	AL-U	Out	3.8×10^{-3}	10.80	1.6×10^{-3}	4.46	8.5
RH-26	AL-U	In	6.3×10^{-3}	17.28	NA	NA	9.79
		Out	6.2×10^{-3}	17.28	NA	NA	14.4
RH-27	AL-L	In	1.9×10^{-3}	5.33	NA	NA	NA
		Out	1.6×10^{-3}	4.61	NA	NA	3.46
RH-30	AL-L	Out	NA	NA	1.6×10^{-3}	4.46	NA
RH-31	AL-L	In	3.1×10^{-1}	8.93	NA	NA	NA
		Out	2.9×10^{-1}	8.21	NA	NA	3.31
RH-33	AL-U	Out	1.5×10^{-2}	43.20	1.3×10^{-2}	37.44	30.24
RH-34	AL-L	In	6.1×10^{-4}	1.73	NA	NA	NA
		Out	7.5×10^{-4}	2.16	NA	NA	NA
RH-35	AL-L	In	2.3×10^{-3}	6.48	NA	NA	2.74
		Out	2.6×10^{-3}	7.34	NA	NA	4.75
RH-36	VOL	In	7.1×10^{-6}	0.02	NA	NA	NA
		Out	8.1×10^{-6}	0.02	NA	NA	0.02
RH-37	VOL	In	3.1×10^{-4}	0.86	NA	NA	0.29
		Out	5.2×10^{-4}	0.55	NA	NA	1.05
RH-38	AL-U	Out	NA	NA	3.1×10^{-4}	0.88	NA
RH-40	VOL	Out	NA	NA	4.3×10^{-4}	1.22	NA
RH-41	AL-U	Out	NA	NA	8.6×10^{-4}	2.45	NA
RH-43	VOL	Out	NA	NA	6.2×10^{-4}	1.73	NA
RH-44	AL-U	Out	NA	NA	2.7×10^{-4}	0.76	NA
RH-46	VOL	Out	NA	NA	3.1×10^{-4}	0.88	NA
RH-47	AL-U	Out	NA	NA	1.2×10^{-1}	3.46	NA
RH-48	VOL	Out	NA	NA	6.0×10^{-1}	17.28	NA

a. AL-U = Upper Alluvium; AL-L = Lower Alluvium; VOL = Volcanics

b. Average well hydraulic conducovity values were determined by the evaluanon of individual test data (i e., consistency, data plot anomalies, etc.). Some values from the table were not used to calculate averages

NA = Not available

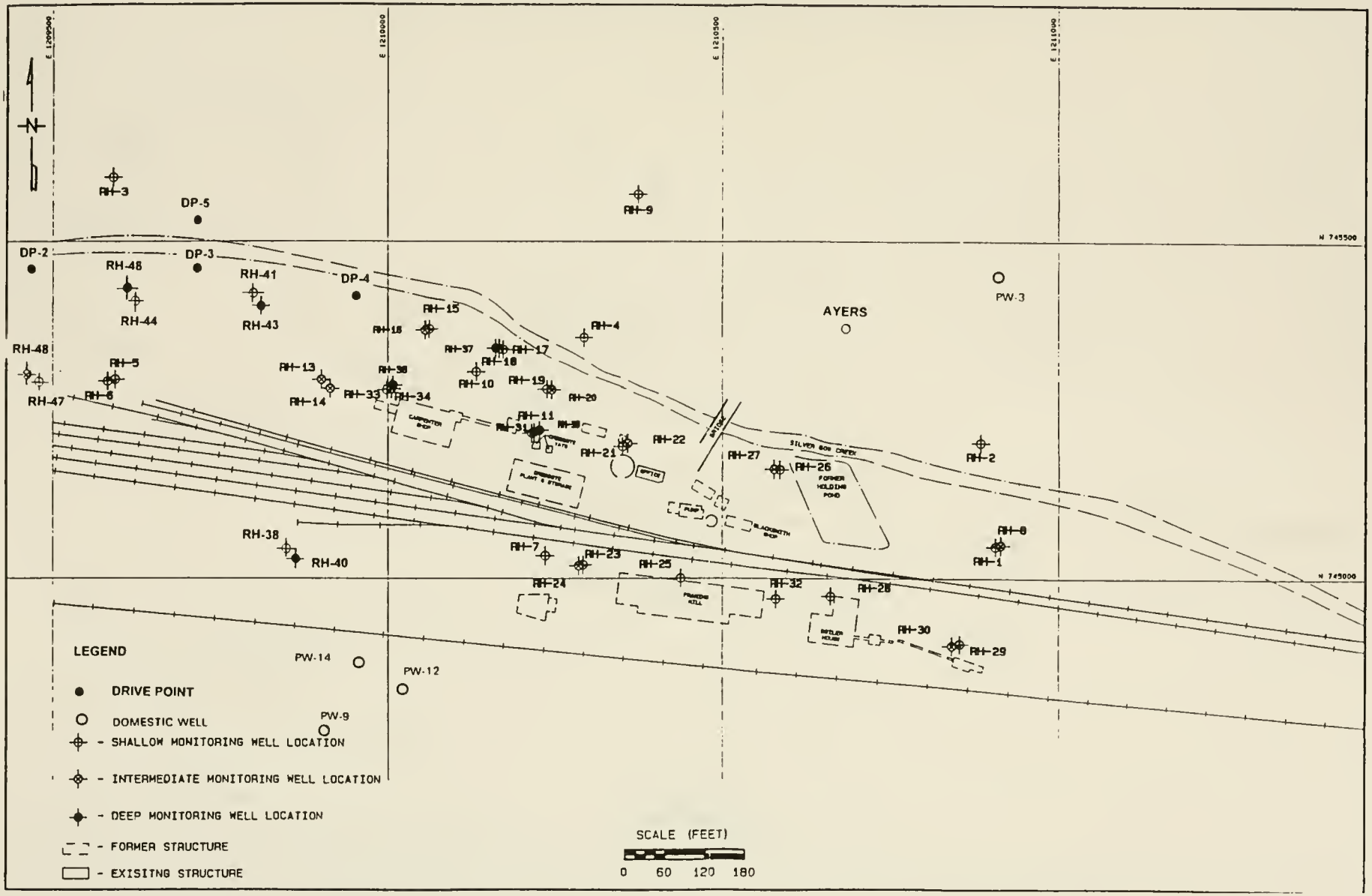

Figure 7: Location of monitoring wells (modified from KER, 1992)

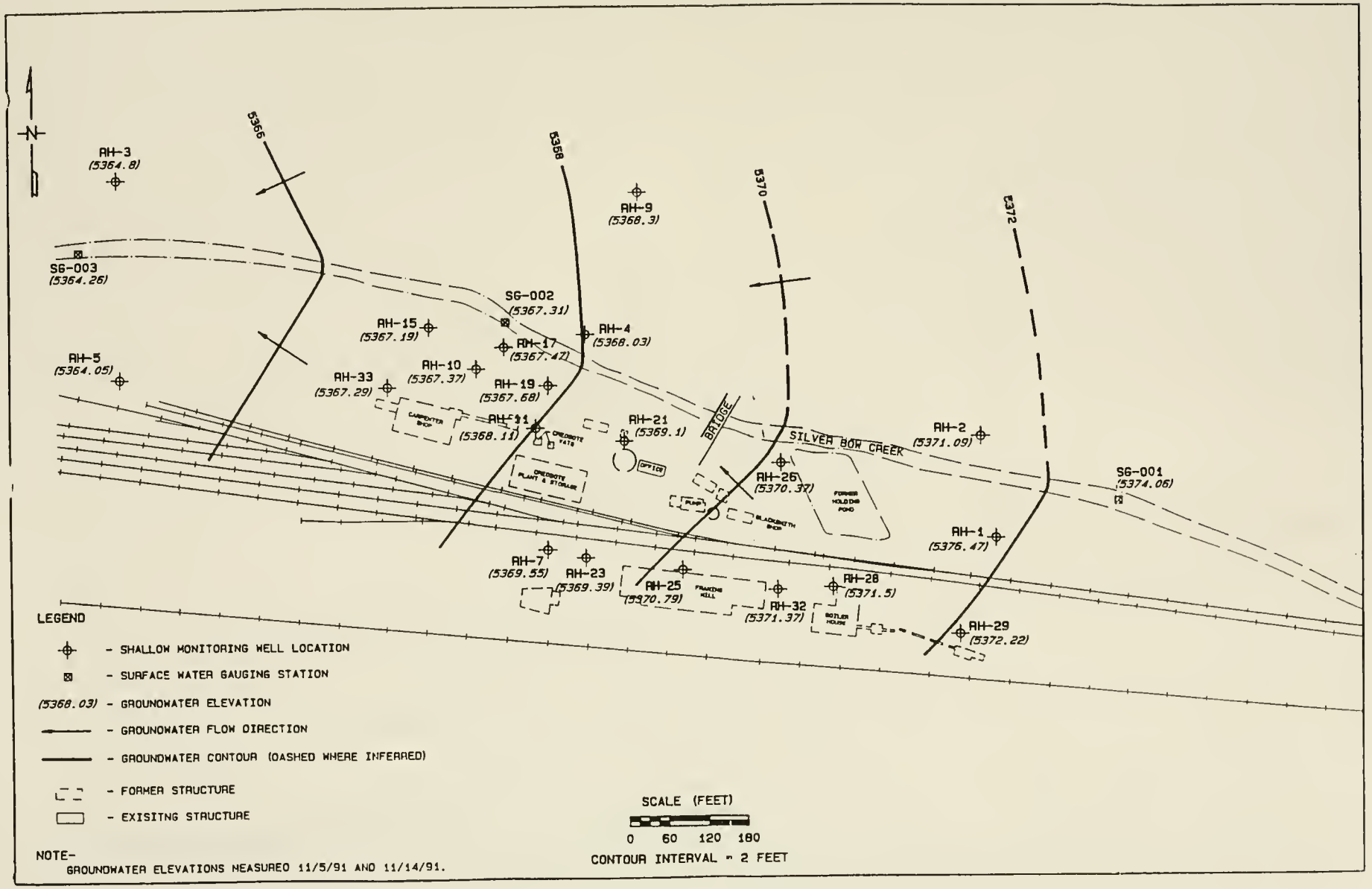

Figure 8: Groundwater elevation contours, shallow depth wells (KER, 1992)

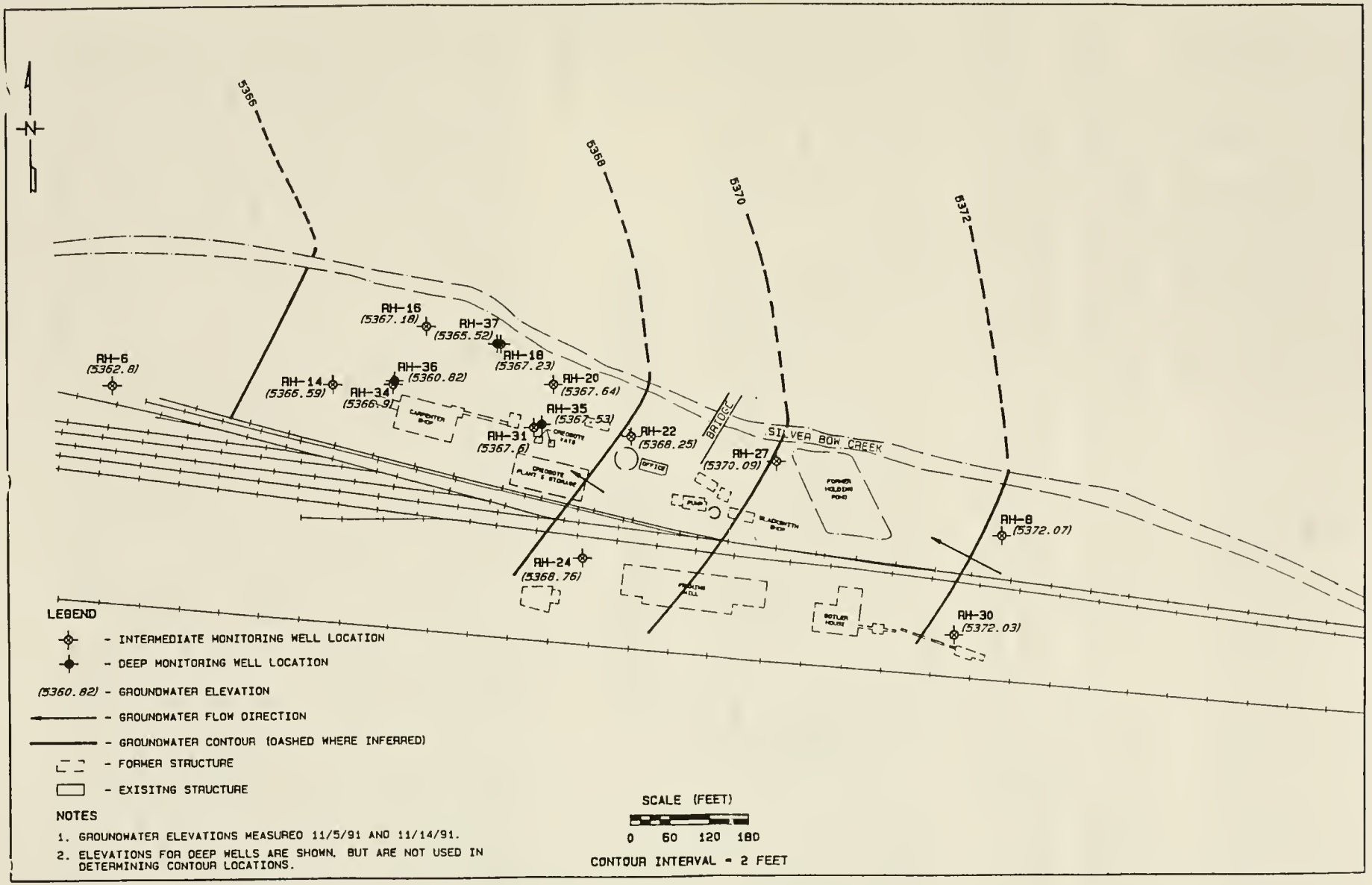

Figure 9: Groundwater elevation contours, intermediate depth wells (modified from KER, 1992).

and 9). The water levels in shallow wells are higher than the stage of Silver Bow Creek and they are also higher than heads deeper in the saturated material. The horizontal gradient was calculated at 0.005 in both the shallow and intermediate depth zones with the vertical gradients being downward with a range of 0.006 to 0.162 (KER, 1992).

The water table fluctuates in part as a result of stage variation of Silver Bow Creek (Figure 10). Long term continuous hydrographs of the water table were not available for evaluation.

Average groundwater velocities in the shallow and intermediate zones representing the alluvial aquifer were estimated using a gradient of 0.005, a range of porosity between 0.20 and 0.45, and a hydraulic conductivity of 9.4 ft/d, to be 0.10 ft/d to 0.23 ft/d.

The average flow of Silver Bow Creek approximately three miles east of the site is 24.4 cfs (Hydrometrics, 1987). Attempts a conducting a synoptic survey in the Rocker area yielded variations in stream flow that fell with in measurement error (ESE, 1994). ESE (1994) note downward vertical groundwater gradients at the site and suggest the creek may be losing water to the groundwater system in the vicinity of the Rocker site. Conceptually, groundwater flow might be viewed as generally down the valley to the west (Figure 8). Groundwater flow in the underlying volcanic aquifer is reported by ESE (1994) to be to the east (Figure 11).

GROUNDWATER INJURY DETERMINATION

Source

Arsenic has been found in the soil at the Rocker Site in concentrations exceeding 10,000 mg/kg. In 1989, approximately 1,021 cubic yards of soil and wood chips contaminated with arsenic were removed from the site. Over 8,800 cubic yards of clean fill were then placed over the site (KER, 1992). Soil removal areas were re-sampled in 1991 (#01 to #90) as well as railroad ballast material (Figure 12). Additional samples from three borings were collected in 1992 to fill in data gaps identified in the 1991 sampling (ESE, 1994). Arsenic was found in all of the 84 subsurface samples (samples taken between 1 and 87 feet below land surface) in 1991 and all samples collected in 1992 (ESE, 1994). Eleven of these samples contained more than 500 mg/kg of arsenic. Fifteen samples contained concentrations of polynuclear aromatic hydrocarbons (PAH) of greater than 1,000 ug/kg, typical hazardous substances related to the creosote preservative process. Soil samples also contain arsenic, cadmium, copper, lead and zinc. The highest concentrations of wastes were associated with the former carpenter shop, creosote plant, holding pond and the area north of the office (Figure 3). Soil borings revealed the highest concentrations of arsenic and PAH's within 12 ft of the surface

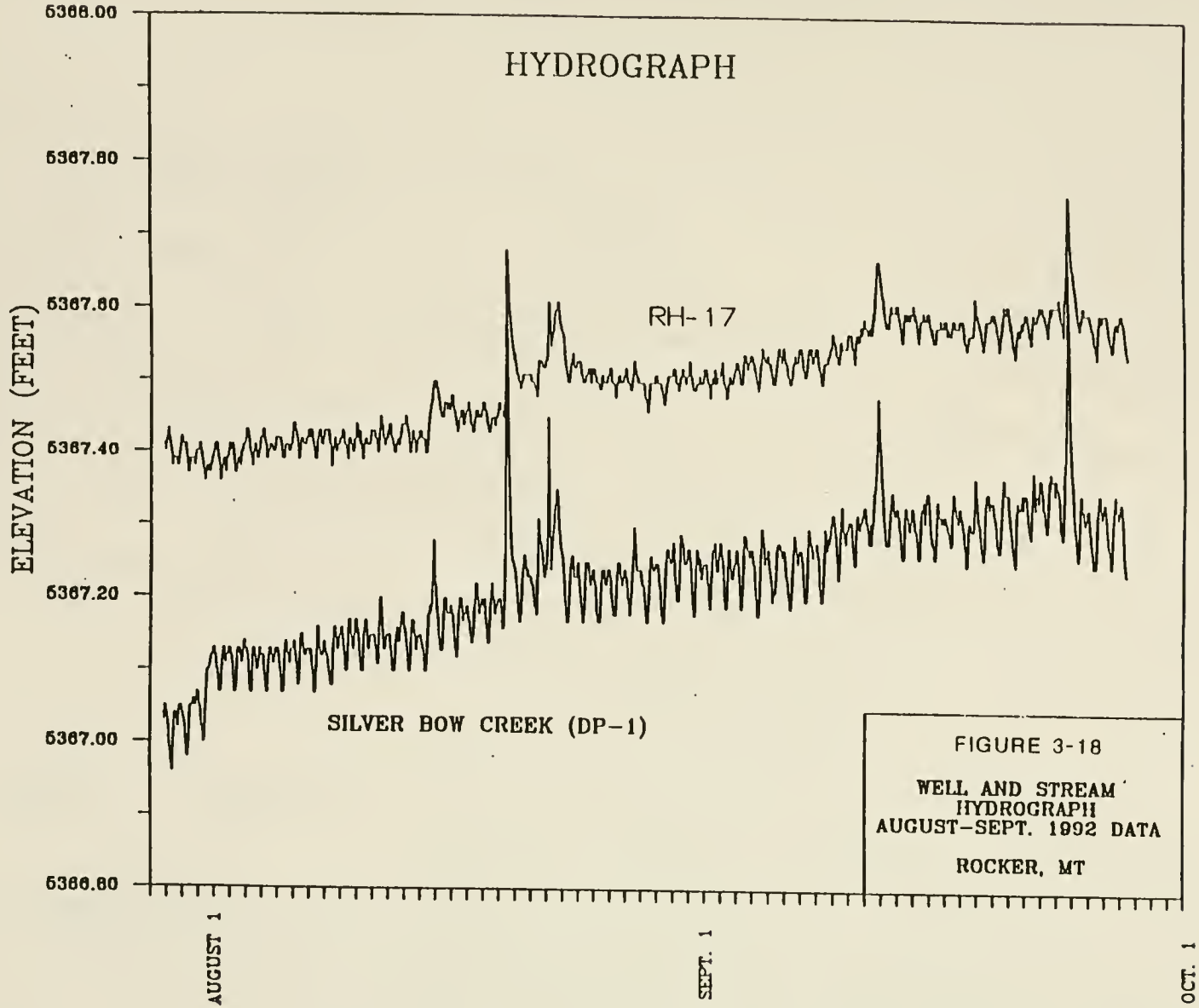

Figure 10: Hydrographs of shallow well RH-17 and Silverbow Creek between August and September 1992 (ESE, 1994).

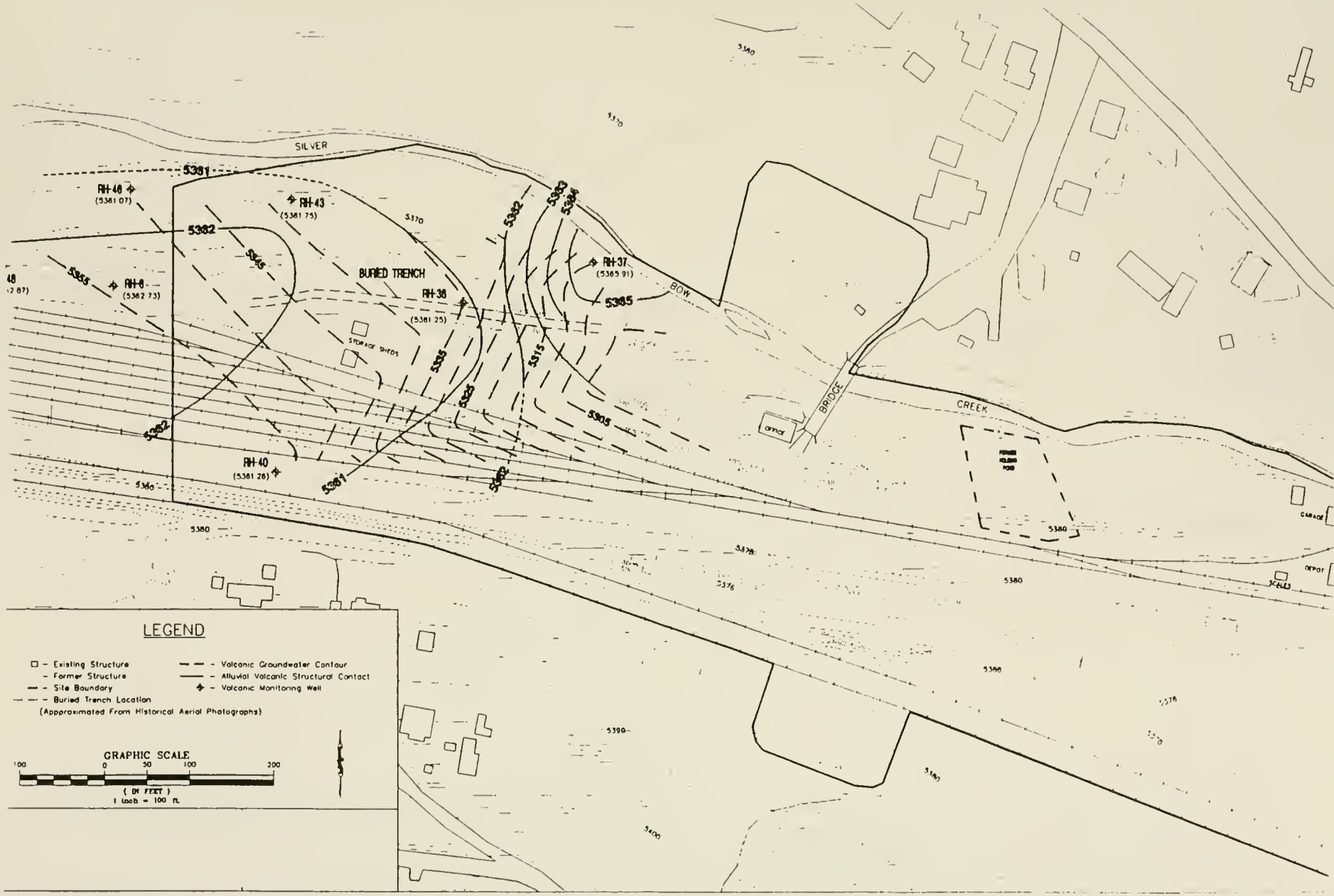

Figure 11: Equipotential surface of the consolidated volcanic aquifer shown in dashed lines (ESE, 1994).

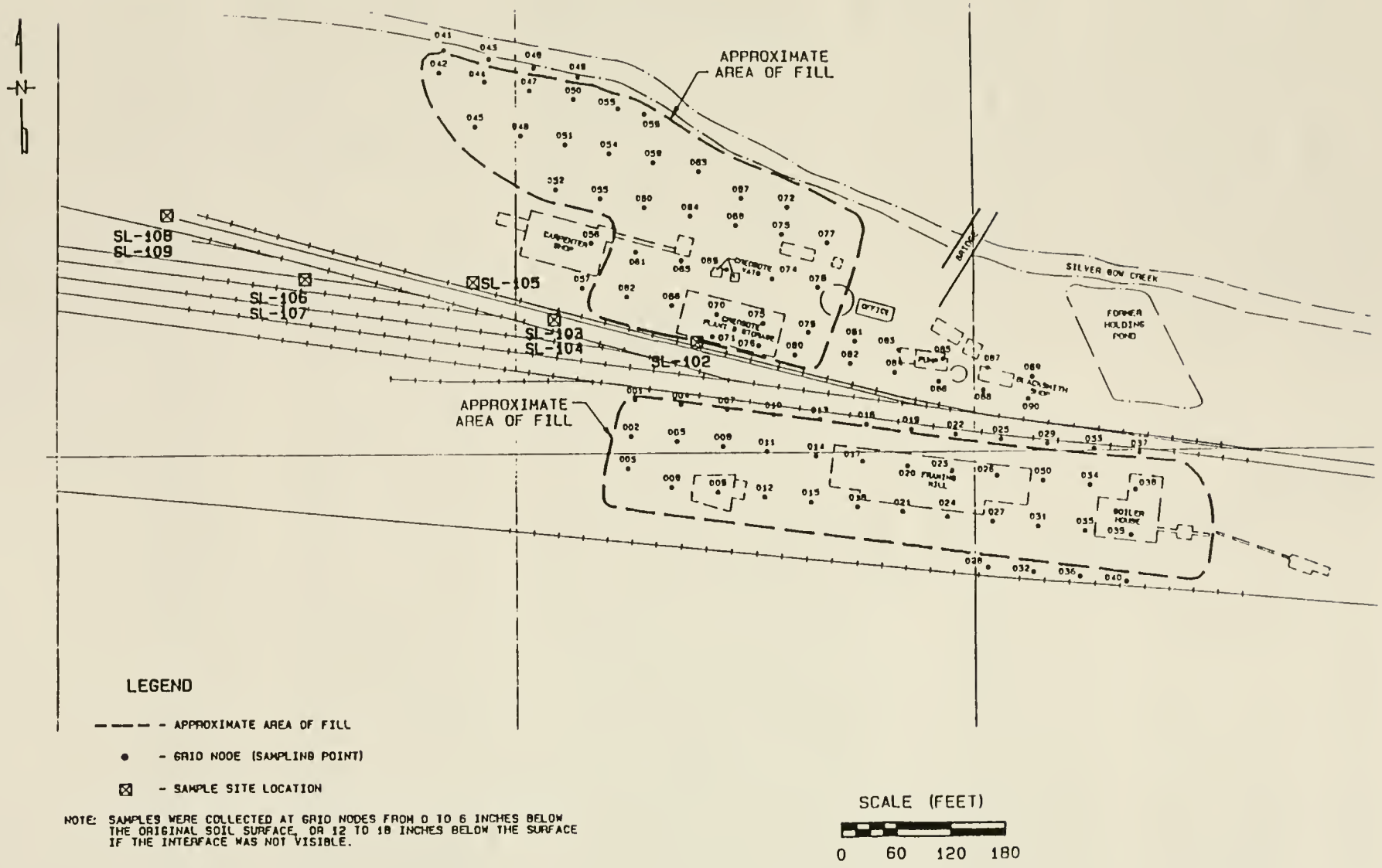

Figure 12: Surface soil sampling sites. Sites #01 to #090 are located in the area of soil removed in 1989 (KER, 1992).

(KER, 1992). PAH contamination was found in virtually all samples taken at a depth of 10 ft or less from the surface (ESE, 1994).

ESE (1994) reported on an attempt to model the movement of moisture through the vadose zone at the site using the Hydrologic Evaluation of Landfill Performance (HELP) model in leu of actual instrumentation of the vadose zone. The results of this effort indicated less than 5% of the precipitation would be available to infiltrate the soils and recharge the groundwater system. No field conformation of this effort has been attempted.

It is clear that arsenic and associated metals originating from the wood preservation process and the use of mine tailings for railroad ballast are present on the site. The use of organic solvents and wood preservatives at the site have also resulted in soil contamination by PAH's. All these compounds have migrated vertically to the water table and contaminated the groundwater system underlying and adjacent to the site.

Manner, Pathway and Duration of the Release

Though a complete history of the plant operation is not available, groundwater contamination from pits, trenches and vats used to hold arsenic solutions and organic compounds, spills of processing fluids, precipitation percolating through contaminated soils, and possibly, infiltration of flood waters of Silver Bow Creek have most likely been occurring since the early 1900's. These processes have probably mobilized wastes and transported them to the shallow groundwater. Downward vertical gradients and high densities of some of the organic wastes allow wastes to move deeper in the saturated zone contaminating part of the intermediate zone. Today, the seasonal variation of the water table and infiltrating water from recharge perpetuate the contamination of groundwater and migration of hazardous substances at the site.

Removal of the highly contaminated surface soil at the site has most likely resulted in some mitigation in the transport of hazardous substances from the soil to the aquifer. However, contamination in the vadose zone has been identified to a depth of at least 12 ft, thus source material is still present on the site (Table 3)(KER, 1992; ESE, 1994). In addition to inorganic contamination, PAH levels in railroad right-of-ways ranged between 100 and 5000 ug/l, and these concentrations were also found in soil samples associated with the location of the site creosote vats (ESE, 1994).

Results of pumping of the Town Pump well site adjacent to the Rocker site resulted in decline in the water levels in wells penetrating the volcanic aquifer (MBMG, 1994). Such pumping over long periods of time may enhance vertical migration of site contaminants.

TABLE 3: Statistical Summary of Metals in Soil at Rocker (ESE, 1994).

	Arsenic	Cadmium	Chromium	Copper	Lead	Zinc
Surface Soils 0.0-0.5 Feet (Exclusive of Railroad)						
Mean	554	12.8	14.2	781	368	1531
Std. Dev	1482	17.4	4.5	677	198	1045
Median	161	5.1	12.5	460	354	1300
Surface Soils 0.0-0.5 Feet (Railroad Only)						
Mean	5258	44.6	11.6	1629	2940	25658
Std. Dev	14148	53.7	13.4	1432	4555	61521
Median	399	35.8	6.7	1265	971	8305
0-2 Feet						
Mean	872	7.1	10.8	1002	581	1529
Std. Dev	1904	8.4	7.5	1375	1065	2238
Median	262	2.9	9.2	376	268	457
1-3 Feet						
Mean	52	1.2	9.1	266	113	249
Std. Dev	80	1.0	1.9	171	64	193
Median	23	0.8	9.0	221	103	203
2-4 Feet						
Mean	673	4	11	884	209	905
Std. Dev	1685	4	6	1559	284	885
Median	68	3	9	298	99	569
3-5 Feet						
Mean	524	23.2	5.3	2677	484	2963
Std. Dev	423	18.2	2.1	1471	374	2060
Median	710	13.0	5.5	3100	694	2730
4-6 Feet						
Mean	383	2.5	6.7	201	145	776
Std. Dev	725	2.7	2.7	226	93	540
Median	25	1.2	8.3	93	188	471
5-7 Feet						
Mean	307	2.1	9.1	441	104	425
Std. Dev	568	2.2	3.1	356	50	368
Median	90	1.3	9.7	261	108	331
6-8 Feet						
Mean	171	3.8	8.3	548	619	1297
Std. Dev	182	4.5	3.7	637	945	1589
Median	114	1.8	7.8	395	239	737

	Arsenic	Cadmium	Chromium	Copper	Lead	Zinc
7-9 Feet						
Mean	167	2.4	10.6	311	82	412
Std. Dev	262	3.1	4.5	207	30	401
Median	59	1.0	11.7	352	78	232
8-10 Feet						
Mean	1062	7.3	8.4	1355	729	2078
Std. Dev	1932	8.7	4.2	1802	1256	2564
Median	136	3.3	8.4	693	179	532
9-20 Feet						
Mean	5896	28.8	8.0	1028	324	1854
Std. Dev	14190	38.9	3.6	1885	467	3122
Median	48	8.2	7.8	384	129	642
36-60 Feet						
Mean	16.3	0.8	9.2	63.9	56.6	95.7
Std. Dev	16.2	0.1	6.4	54.6	40.8	80.7
Median	11.4	0.7	5.8	39.7	48.0	40.1
61-80 Feet						
Mean	10.3	0.7	9.8	50.9	60.2	81.2
Std. Dev	9.5	0.0	3.3	38.3	37.7	52.2
Median	7.8	0.7	9.7	42.4	57.4	71.3
82-109 Feet						
Mean	7.8	0.8	5.9	14.0	17.8	30.6
Std. Dev	10.4	0.1	2.2	3.0	3.3	12.9
Median	2.8	0.8	5.4	14.1	17.5	28.4

Relevant Standards

The groundwater resources in the Rocker area are used for stock, domestic and industrial supply (KER, 1991). Thus the primary and secondary drinking water standards are considered relevant when assessing injury to the groundwater resources in the Rocker area. Review of water quality data for groundwater sampling sites in the Rocker region revealed concentrations of individual constituents exceeded standards listed in Table 4. Concentrations of organics were present in water samples from some of the wells in the Rocker area. Most constituents including PAH compounds were related to the creosote process.

Data Assessment

Appendix A contains a database that lists groundwater samples and concentrations of constituents that were determined to exceed standards at the Rocker Site. This data base does not include organic compounds. Table 5 presents the organic constituents found in wells for which standards have been set. Values for total PAH's were listed in the appendix as an indicator of organic contamination. Because many values of regulated compounds are not allowed to exceed 1 ug/l, values in this range are of concern. The database presented in Appendix A was constructed principally from data presented by Hydrometrics (1988 and 1989), CH2M Hill and Chen-Northern (1990) and KER (1992). Data from one monitoring well and six domestic wells off site were added to the data base from the work of Stiller (1985). Appendix A lists the values as they appear in the source reports, data qualifiers included. Below detection values are indicated by the qualifier "U" next to the value, which is the detection limit for that data point. When a value for a particular analyte in a study is not given, listed as not analyzed, listed as not required, or is rejected, the value is left blank. The source of each data point is indicated in the database as well as the date the sample was taken. Samples are listed by well number and sample date.

Appendix B contains a second set of data adjusted for detection limits. Values listed as U in Appendix A were replaced with values equal to one-half the reported value. These values were then evaluated and median concentration values were calculated for each well and reported in Appendix C. All reports included QA/QC information. The QA/QC data presented by Stiller (1985) was not as detailed as QA/QC data presented in the later reports.

GROUNDWATER INJURY QUANTIFICATION

Water quality data were compiled for 40 monitoring wells in and adjacent to the Rocker Site, and for 15 domestic water supply wells and one monitoring well within two miles of the site (Appendix A and Figures 7 and 13). Water quality samples from multiple wells separated by greater than 100 ft exceeded drinking

TABLE 4: Primary and Secondary Drinking Water Standards Exceeded at the Rocker Site (USEPA, 1992)

Constituent	Primary	Secondary
Arsenic	50 ug/l	
Cadmium	5 ug/l	
Copper		1.0 mg/l
Lead	50 ug/l	
Sulfate		250 mg/l
Iron		300 ug/l
Manganese		50 ug/l
Zinc	5 mg/l	
Benzene	5 ug/l	
Benzo(a)anthracene	0.1 ug/l	
Benzo(a)Pyrene	0.2 ug/l	
bis (2-ethylhexyl) phthalate	6 ug/l	

TABLE 5: Organic Constituents Exceeding Standards at Rocker*.

Well	Date	Organic Compound	ug/l	STD ug/l
RH-1	23-Sep-87	bis (2-ethylhexyl) phthalate	25	6
RH-7	8-Nov-91	Benzo(a)Pyrene	32	0.2
RH-11	24-Sep-87	Benzene, 1-ethyl-2-methyl	6	5
		Benzene, 1,2,3, trimethyl	9	
		Benzene 1-ethyl-3-mehtyl	13	
		bis (2-ethylhexyl) phthalate	4-9	6
	6-Nov-91	Benzo(a)anthracene	10	0.1
RH-9	23-Sep-87	bis (2-ethylhexyl) phthlate	47	6
RH-21	8-Nov-91	Benzo(a) Pyrene	32	0.2

* Other compounds mostly associated with Polynuclear Aromatic Hydrocarbons were found in samples, however no standards were available for comparison.

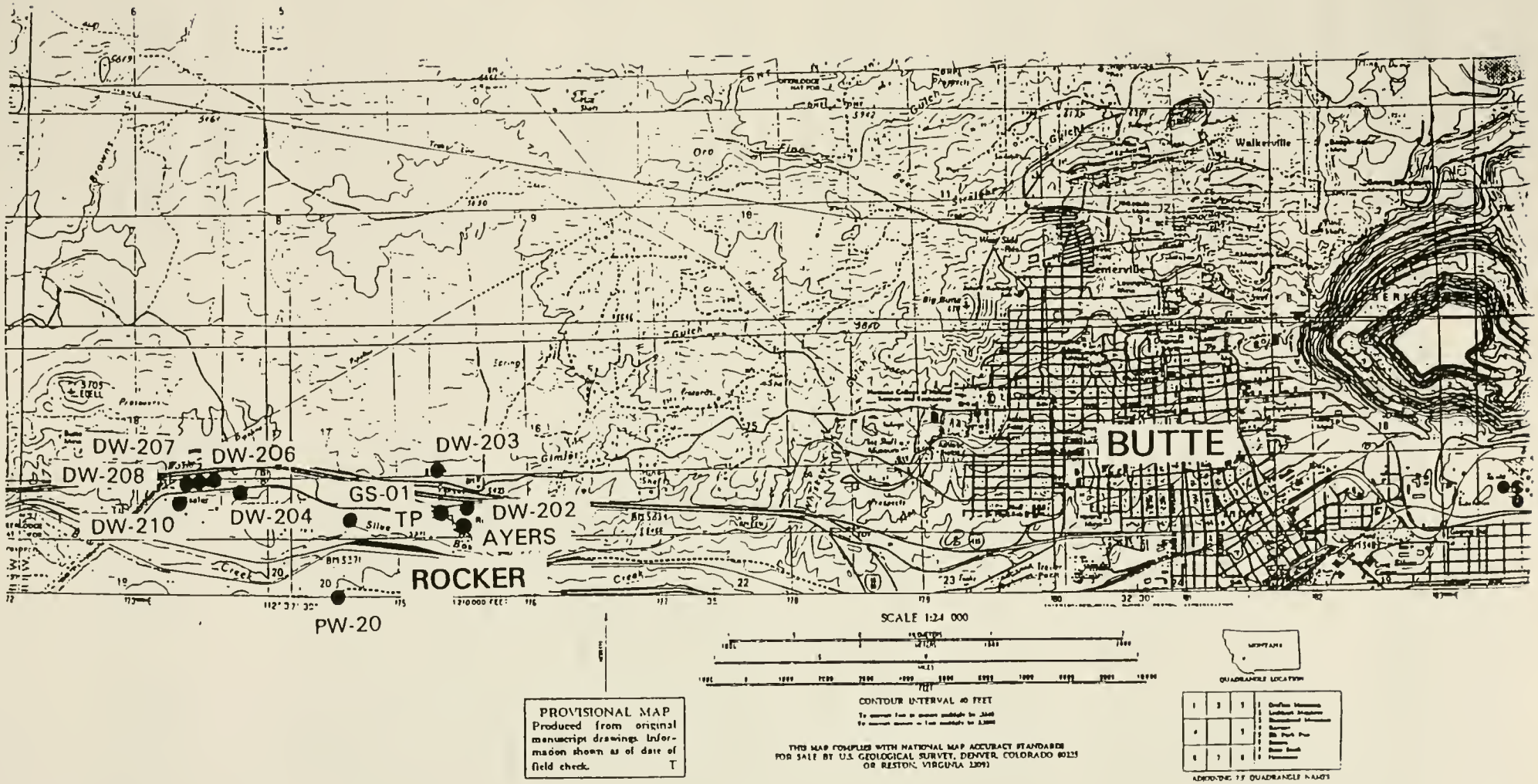

Figure 13: Location of one monitoring well (GS-1) and domestic wells (DW) and AYERS, and the Town Pump Well, TP, in the vicinity of Rocker, Montana.

water standards for one or more constituent at the Rocker Site. Wells located outside of the plant area were typically not contaminated with plant site hazardous substances.

Baseline Conditions

Wells selected to represent background were chosen from published water quality data within a two mile radius of the Rocker Site (Table 6). Wells were completed in permeable sediments similar to those found at the site. Some shallow monitoring wells (RH) south and up gradient of the site, and uncontaminated intermediate depth monitoring wells (RH) beneath portions of the site were also included in the baseline. Other water quality analyses from wells located principally west and down-gradient from the site were included in the baseline as well.

The baseline or control area groundwater quality in the Rocker area was determined by evaluating the median concentration data reported in Appendix C. The criteria used to designate groundwater quality data as baseline included the conditions that:

1. Wells were located in a similar geologic setting;
2. Wells were located in a similar groundwater flow system;
3. Wells were relatively close to the contaminated area;
4. Wells were completed in the same aquifer material type;
5. Water quality data were available.

Median concentrations were calculated by ranking all water quality data collected at each of these sites for each constituent. However, complete chemical analyses were not performed on all samples from these wells. All chemistry data were grouped and ranked by constituent, and median background concentrations determined (Table 7). It was assumed that both shallow and intermediate background water chemistry is represented by these data as the discontinuous nature of the sediments and common source of recharge to the materials result in a single groundwater system.

Existing domestic wells used to represent background conditions are providing potable supplies to the users. Some of these wells may be located in the volcanic aquifer underlying or adjacent to the Rocker site. Baseline monitoring wells in the vicinity of the site would also provide potable water within the limits of the water quality analysis reported. However, extended pumping of shallow or intermediate baseline monitoring wells at the Rocker site may induce the movement of contaminated groundwater to these wells and make them unsuitable for use as drinking water sources (MBMG, 1994).

Extent of Injured Groundwater

The original assessment of the Rocker Site separated groundwater into a shallow and intermediate zones. Though it was later recognized that the 50 to 60 ft of saturated sand, silt and

TABLE 6: Wells with Samples of Groundwater Considered as Background Water Quality in the Rocker Area.

Well #: Ayers, DW-202, DW-203, DW-204, DW-206, DW-207, DW-208, DW-210, GS-1, PW-3, PW-9, PW-12, PW-14, PW-20, RH-16, RH-18, RH-22, RH-23, RH-34, TPUMP

TABLE 7: Median Concentrations of Constituents Listed on Table 6 for Background Groundwater.

Constituent	Back Ground Concentration	n
Arsenic	10 ug/l	(22)
Cadmium	1 ug/l	(18)
Copper	10 ug/l	(18)
Lead	1 ug/l	(18)
Zinc	17 ug/l	(18)
Iron	10 ug/l	(31)
Manganese	4 ug/l	(4)
Sulfate	103 mg/l	(17)
PAH	2 ug/l	(2)

clay behaved as one unconfined system, water quality interpretations were performed based on the shallow and intermediate classification.

Median values were grouped by the author into two water quality regions for both the shallow and intermediate zones using linear interpolation. The regions either contained groundwater with concentrations less than or greater than drinking water standards. Maps were produced for each constituent exceeding drinking water standards (Figures 14 to 26). Maps of lead were not produced as median values did not exceed MCL's. Also median concentrations of cadmium, copper and zinc were not produced for the intermediate portion of the aquifer as median concentrations did not exceed MCL's. Maps showing the area in which one or more constituent exceed drinking water for each zone were also generated by assembling map area exceeding drinking water standards for individual constituents (Figures 27 and 28). Construction of sharp water quality boundaries was hampered by the lack of monitoring wells surrounding the site that clearly indicated the full extent of the contamination. A second factor effecting the location of the boundaries is the lack of complete chemical analysis of groundwater samples taken from existing monitoring wells. When water quality data were not available for wells considered representative of background conditions, the wells would be included in a mapped area representing exceedence of a constituent if trends could be interpolated over the location of the well. Uncertainty in the location of the boundary resulted in the use of a dashed line to indicate inferred boundaries on the maps produced. Actual boundaries may incorporate greater or smaller areas of contamination above drinking water standards.

Areas of aquifer interpreted to be contaminated by individual hazardous substances are principally found associated with the plant site south of Silver Bow Creek. However, when water quality data or trends were interpreted to exceed standards north of the creek, the map area of contaminated groundwater was extended across Silver Bow Creek to the north. The groundwater flow directions are generally to the creek, however, there are downward vertical gradients and the creek appears to be losing water. Based on this complex hydrogeologic system, groundwater exceeding drinking water standards north of the creek was classified as possibly effected by the Rocker Site sources and included in the area, volume and flux calculations. A portion of the groundwater found on either side of the creek may become degraded by contaminated sediments associated with the floodplain. However, no data are available by which sources of contamination can be separated.

Areas encircled as containing contaminated groundwater in the shallow aquifer were considered to have an average saturated thickness of 12 ft. Thus volumes of contaminated groundwater in the shallow zone were computed by planimetering the encircled area, and multiplying the area by 12 ft and a porosity range of 0.20 to 0.45 (ESE, 1994). The volume of contaminated water in the intermediate zone was calculated by multiplying the planimetered

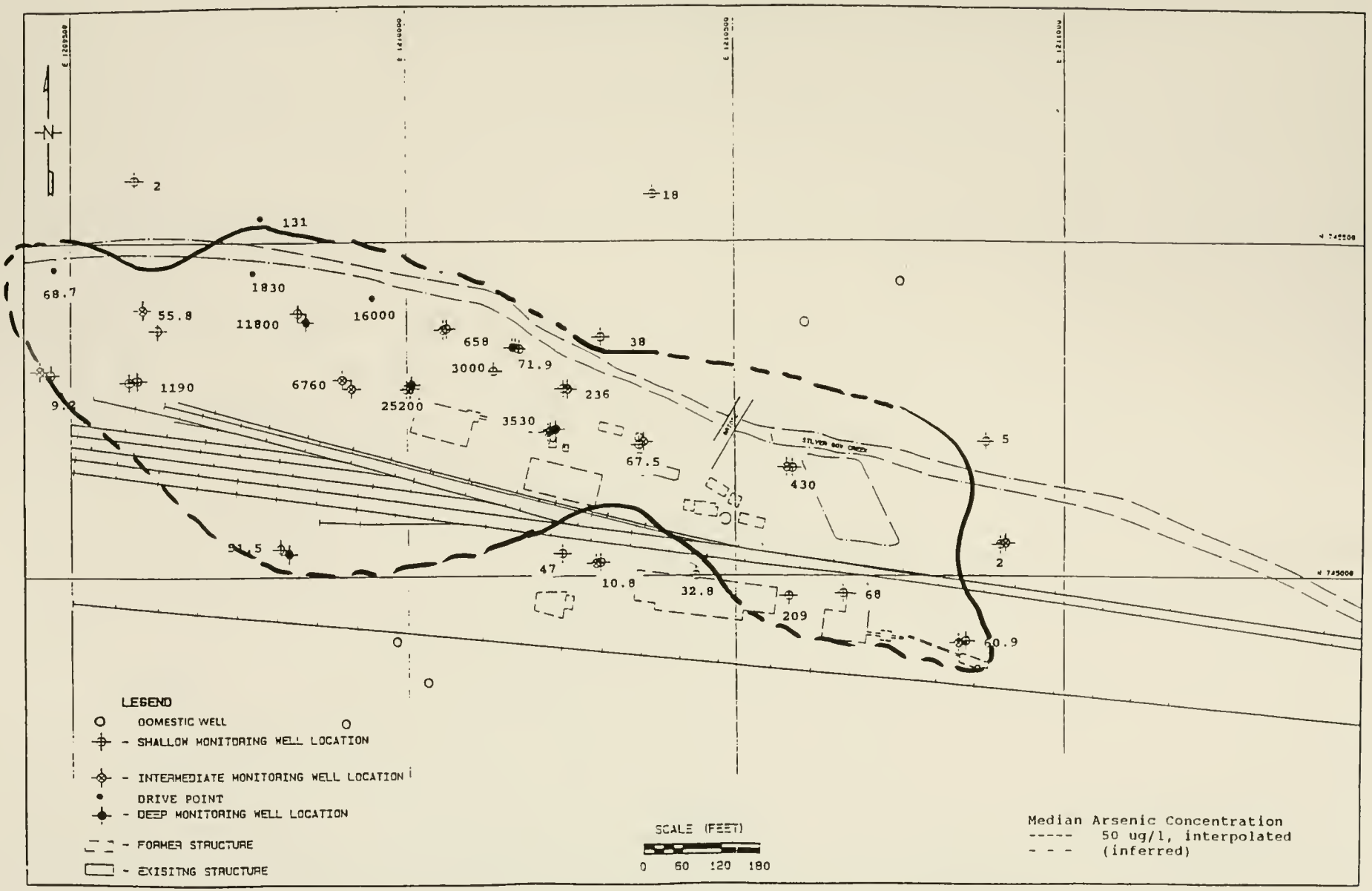

Figure 14: Median concentrations of arsenic in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

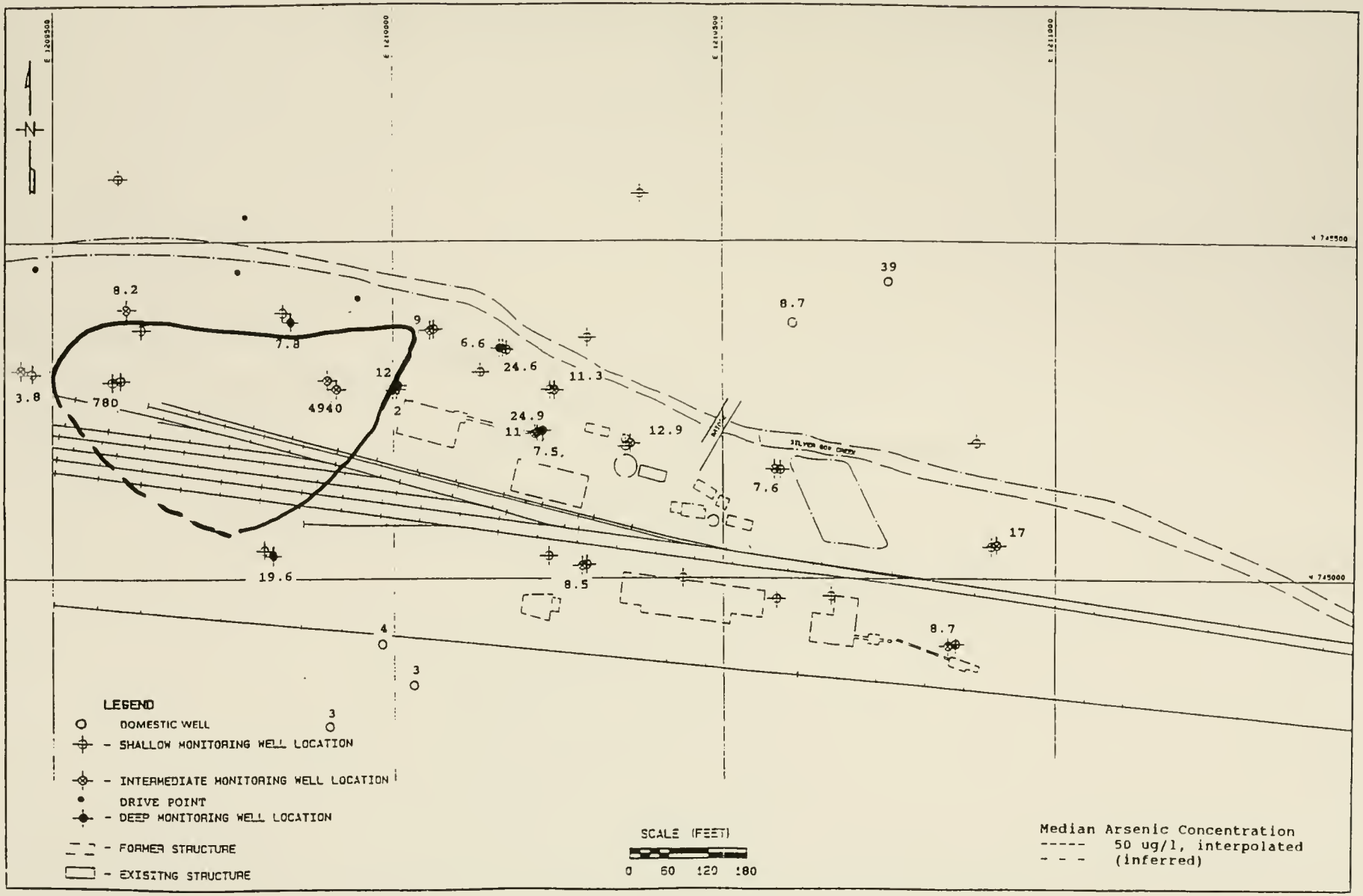

Figure 15: Median concentrations of arsenic in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

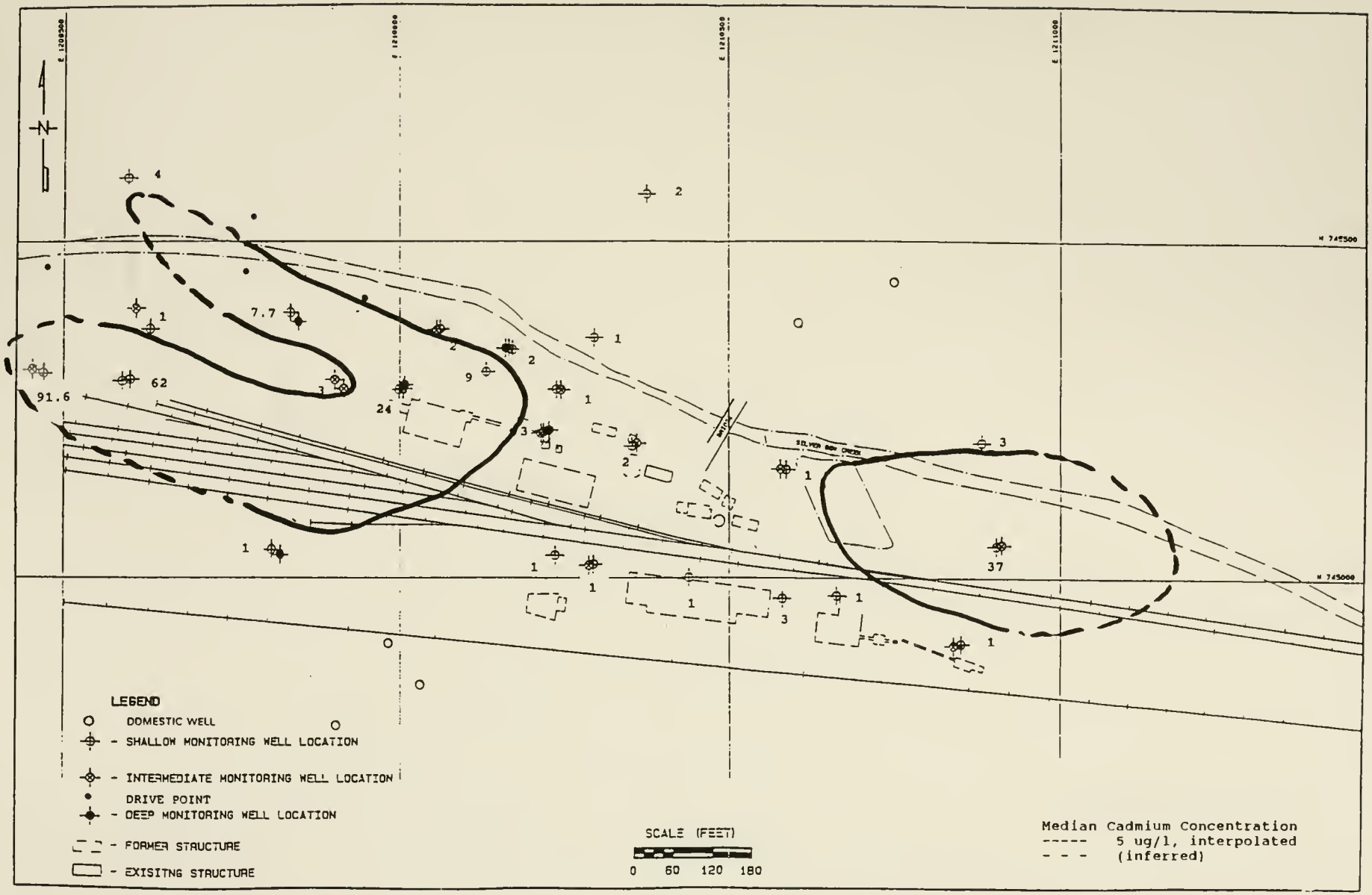

Figure 16: Median concentrations of cadmium in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

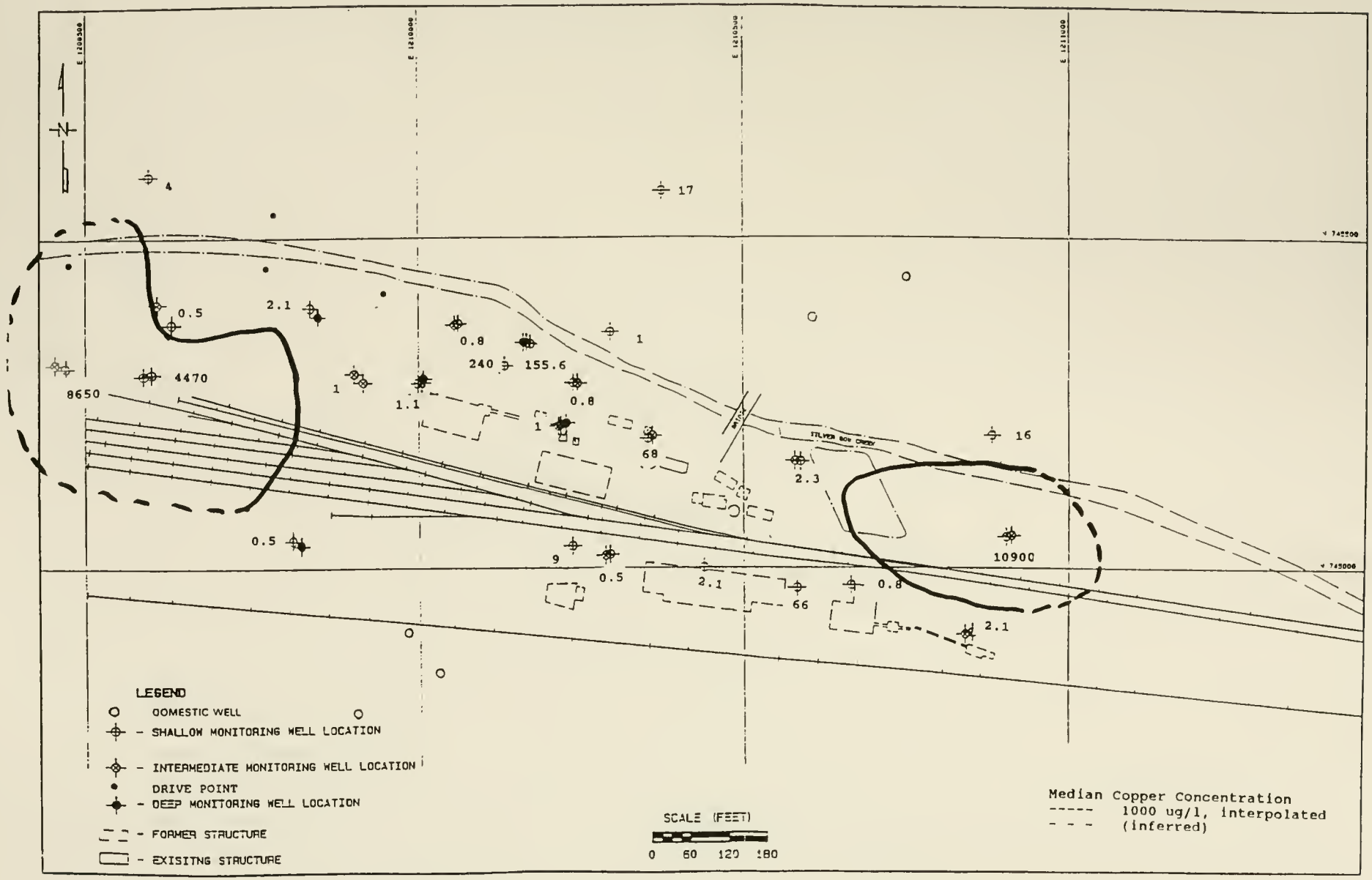

Figure 17: Median concentrations of copper in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

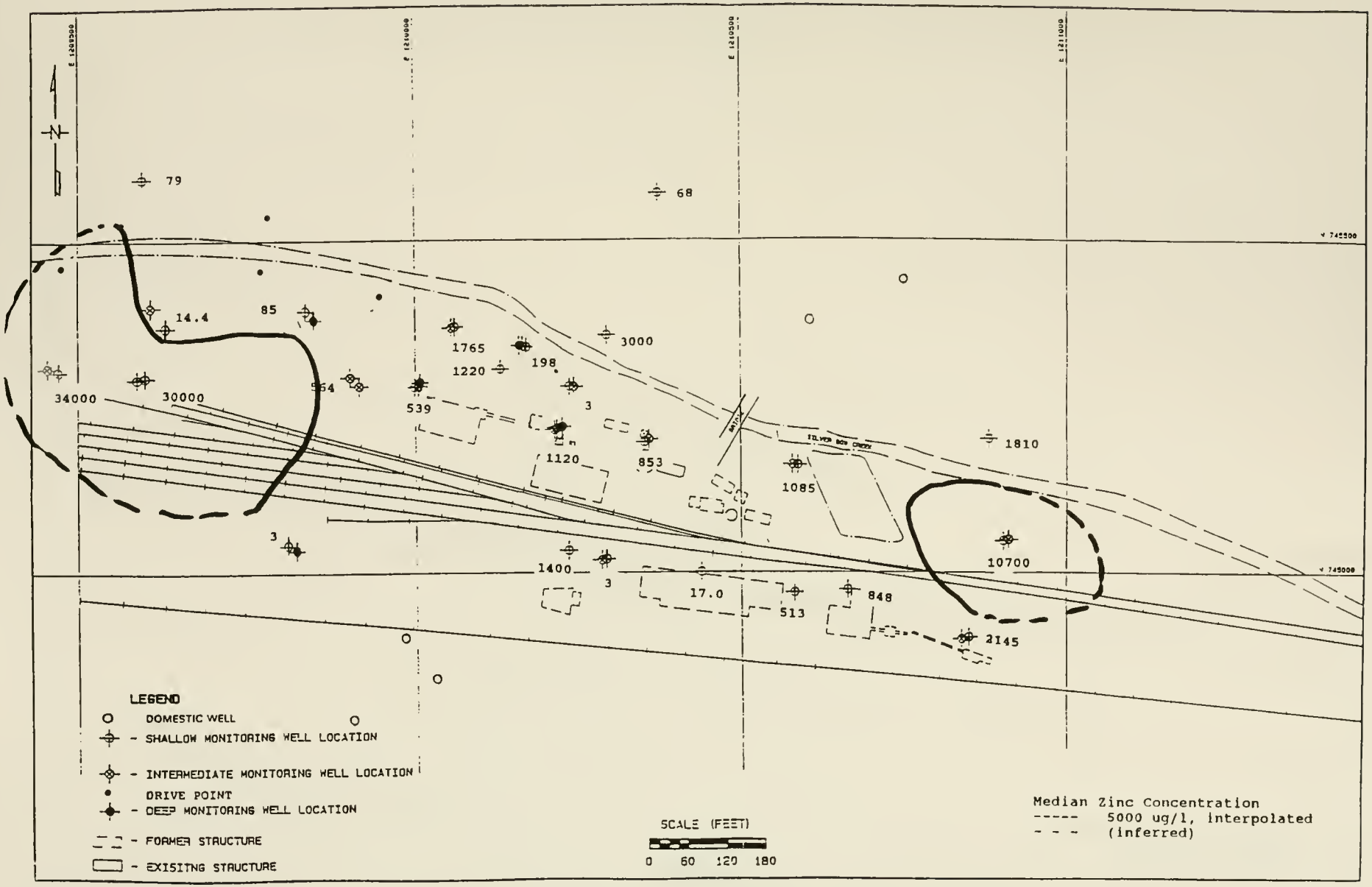

Figure 18: Median concentrations of zinc in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

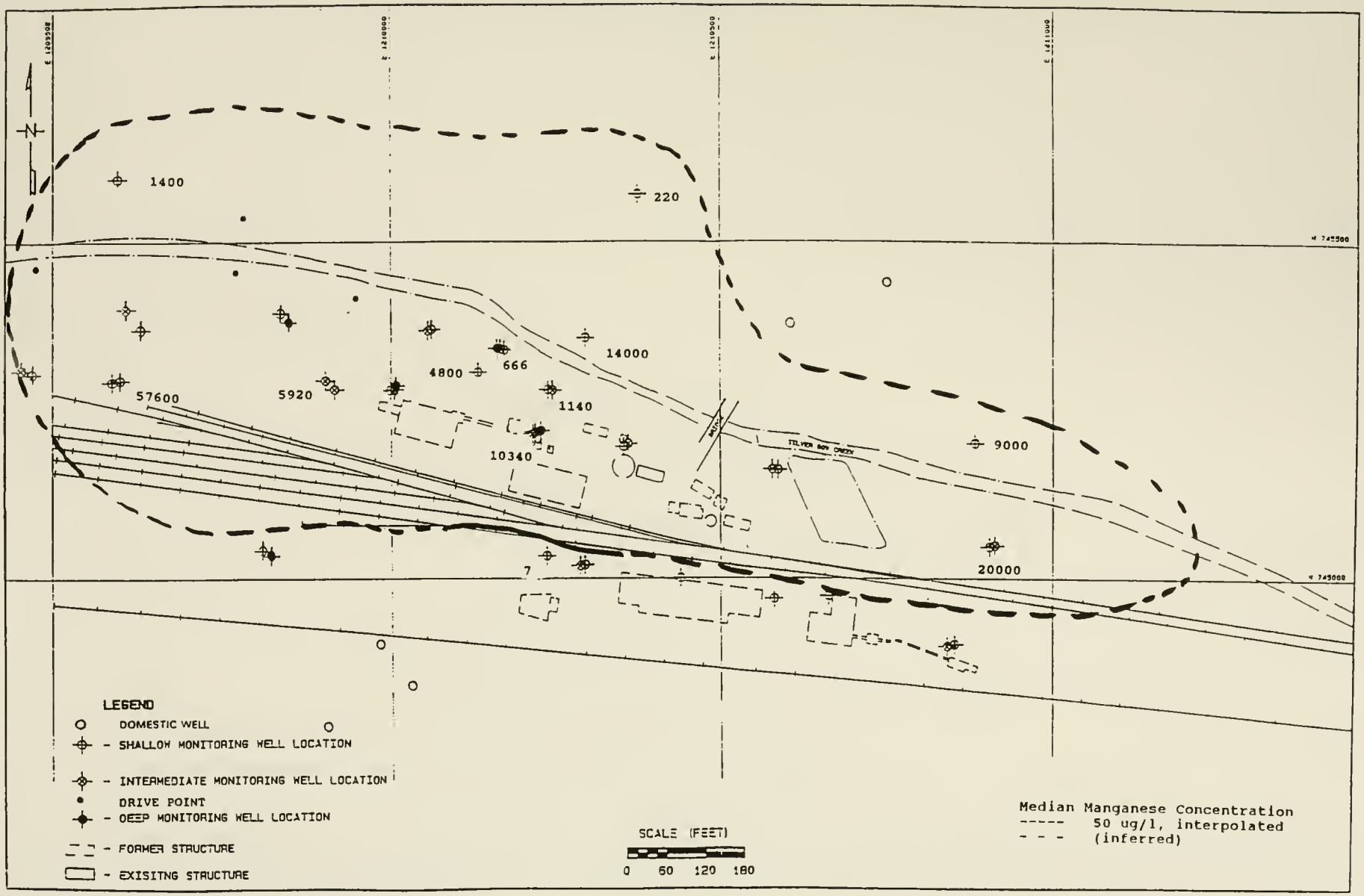

Figure 19: Median concentrations of manganese in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

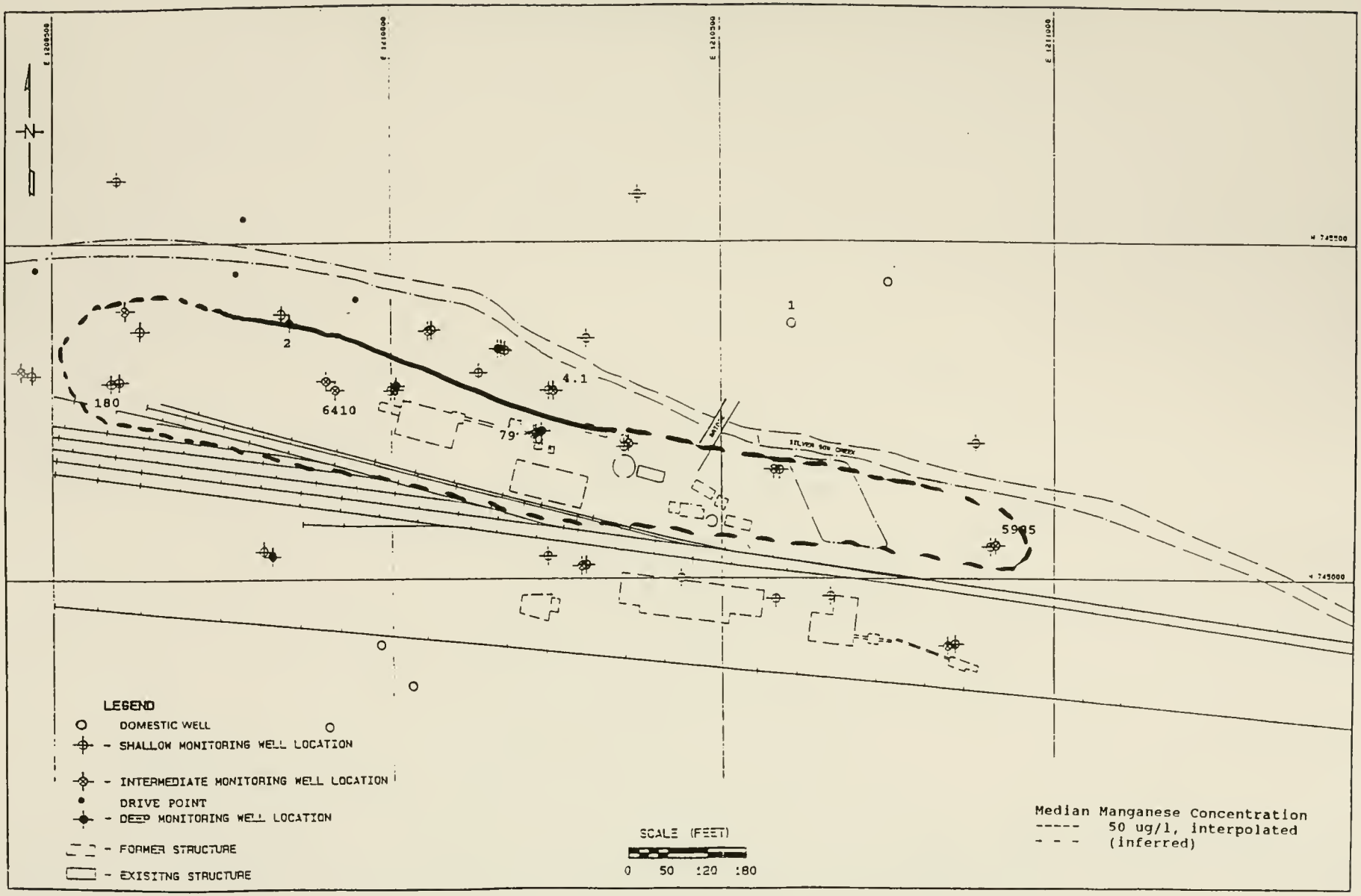

Figure 20: Median concentrations of manganese in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

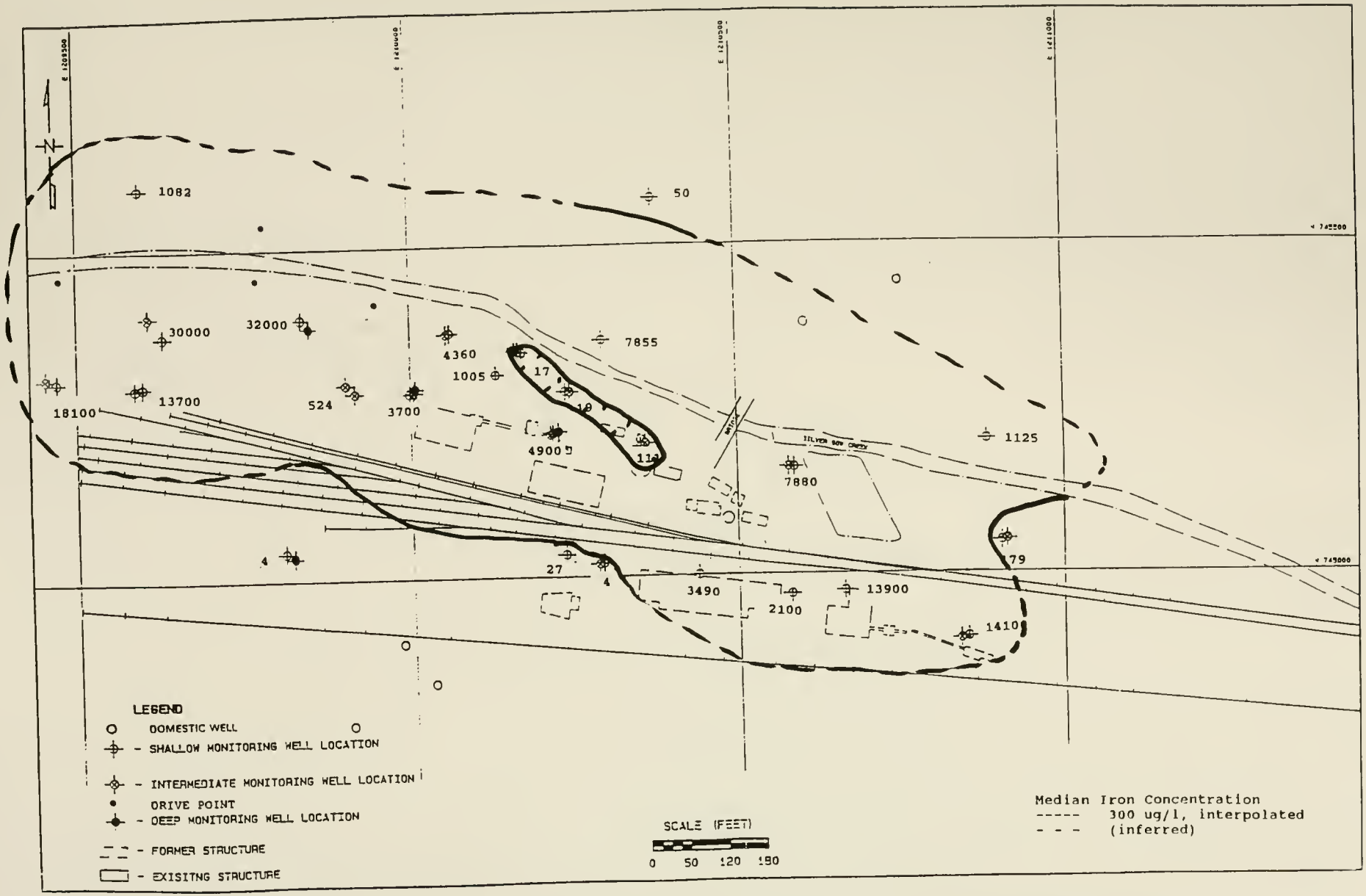

Figure 21: Median concentrations of iron in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

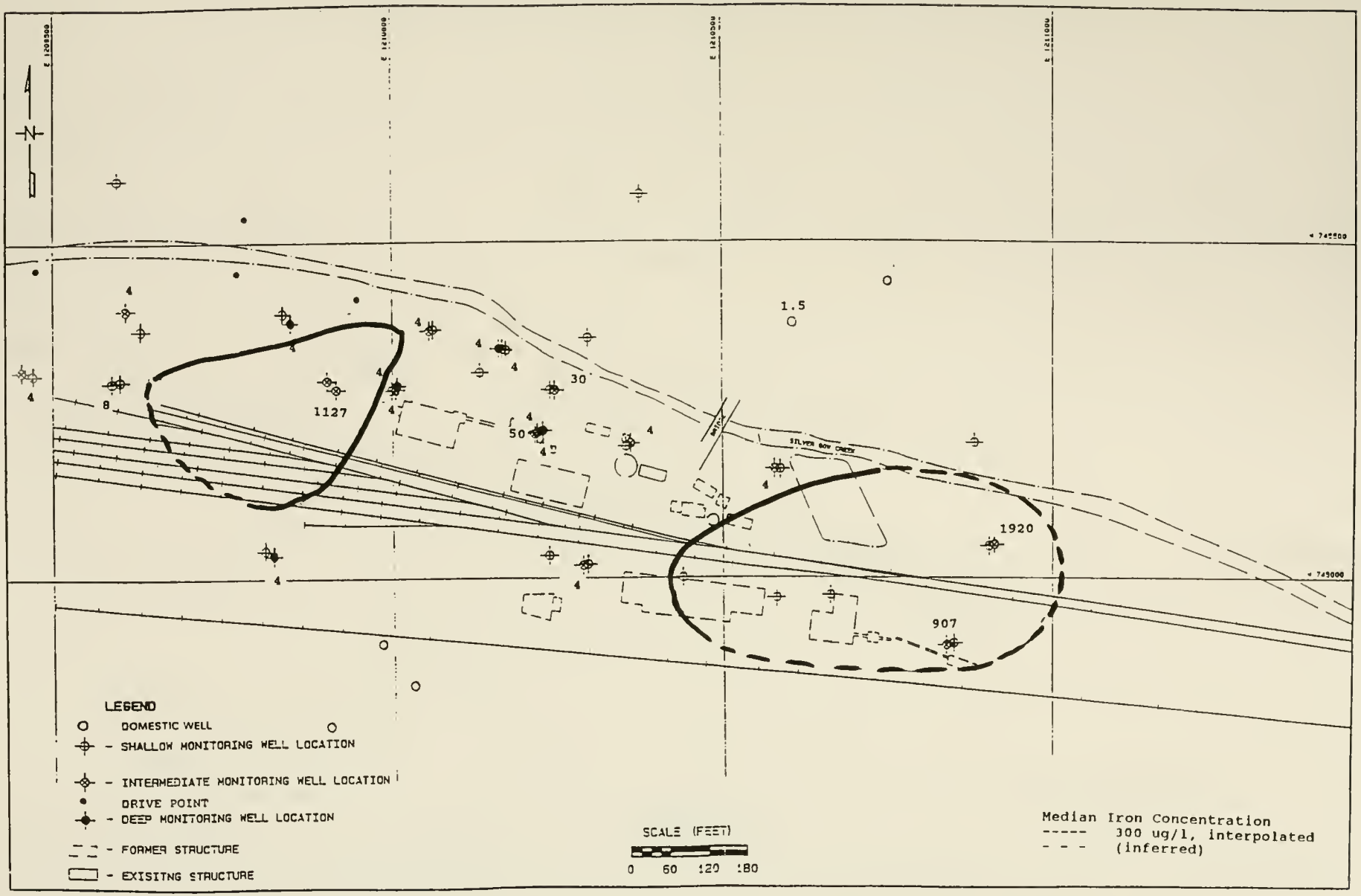

Figure 22: Median concentrations of iron in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

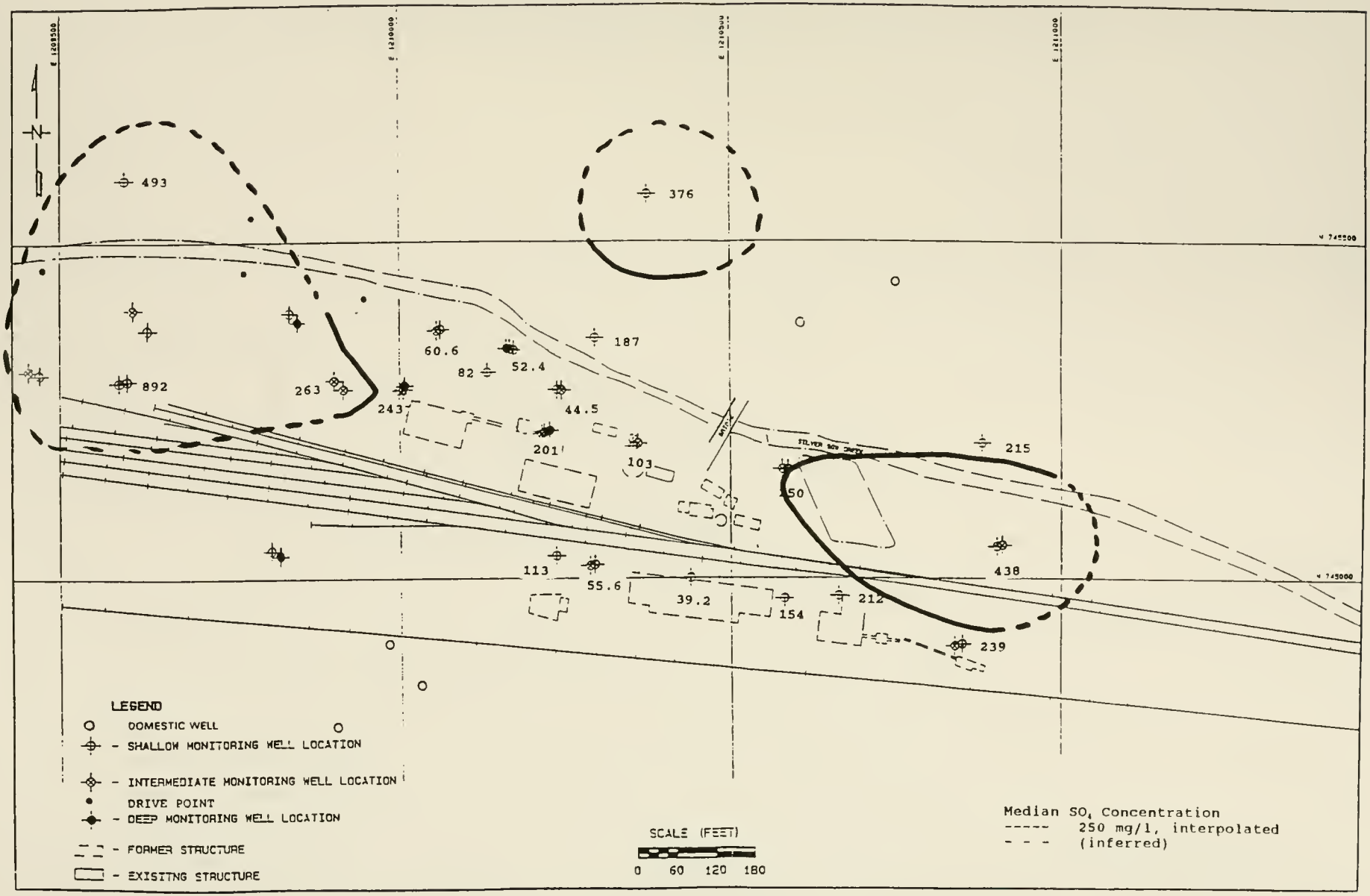

Figure 23: Median concentrations of sulfate in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

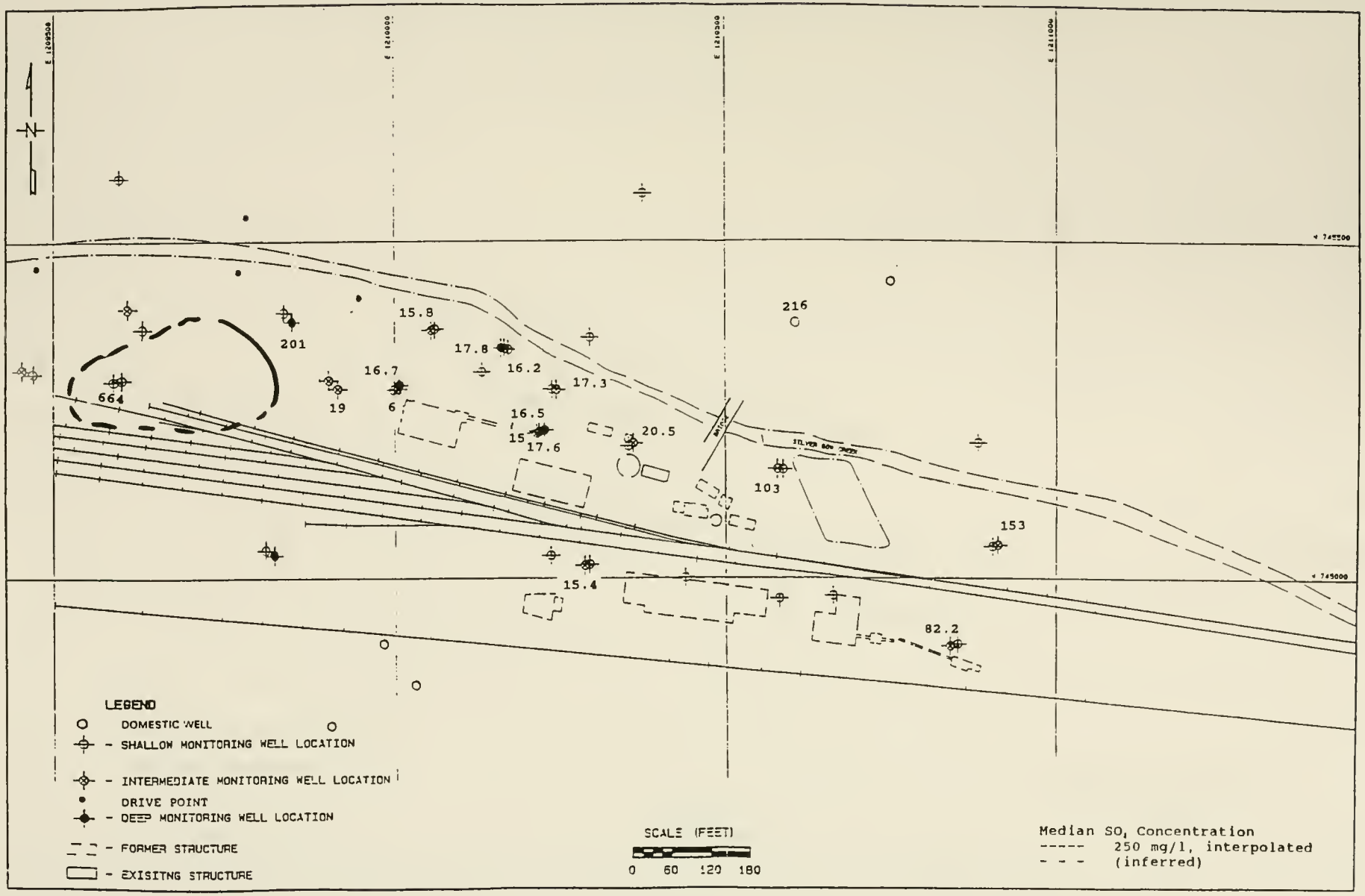

Figure 24: Median concentrations of sulfate in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

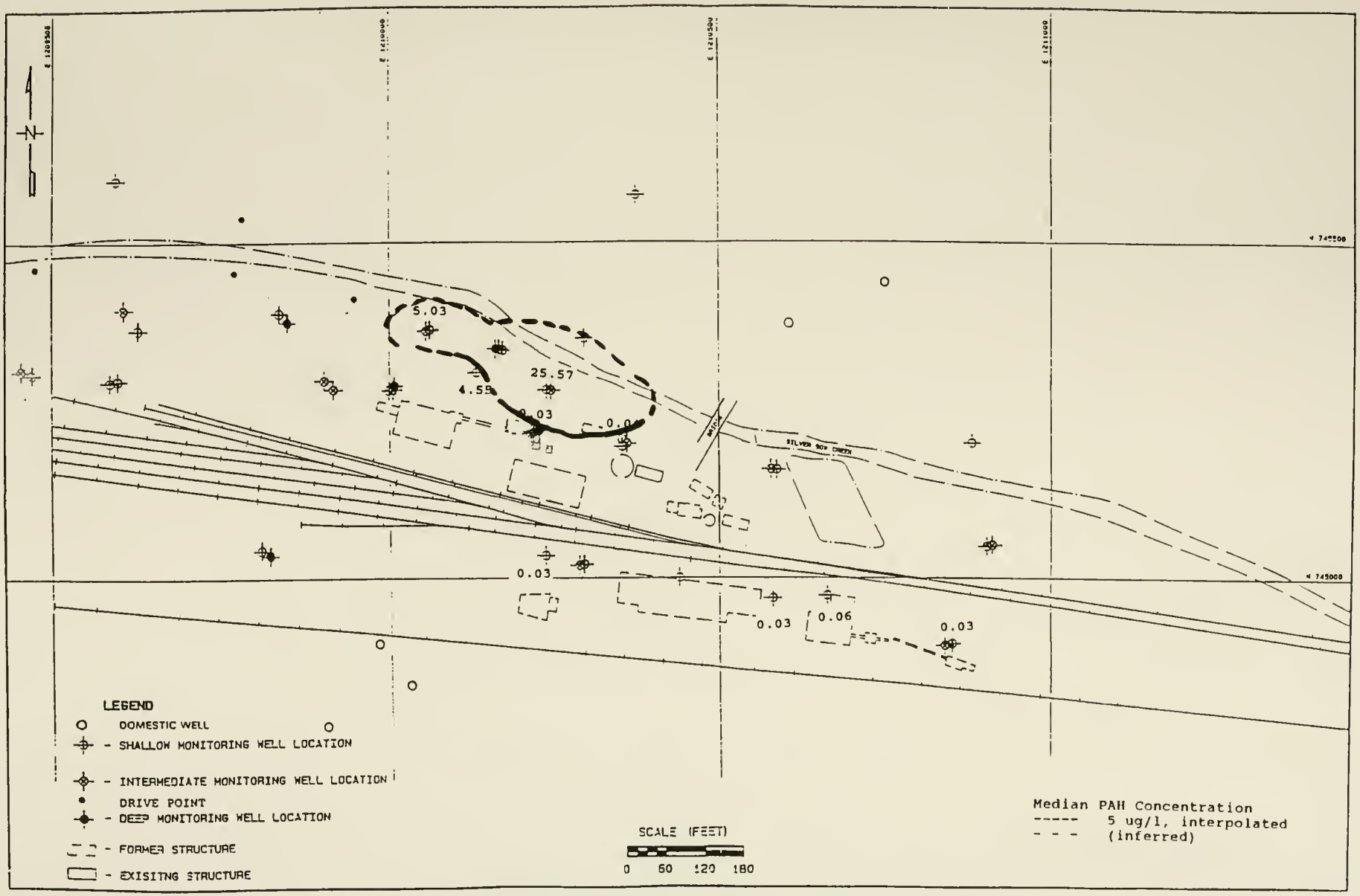

Figure 25: Median concentrations of PAH's in groundwater from shallow zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

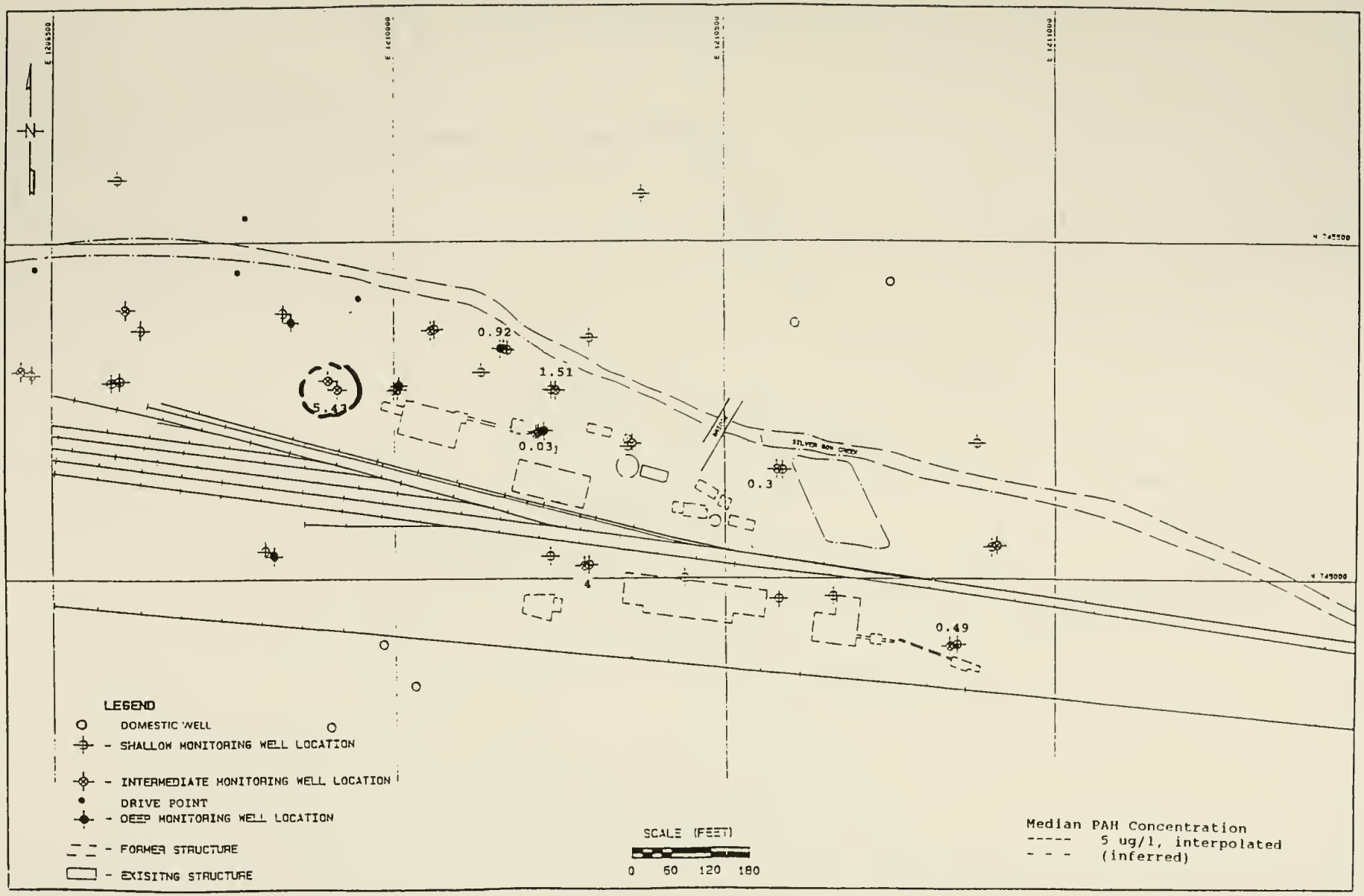

Figure 26: Median concentrations of PAH's in groundwater from intermediate zone wells with areas exceeding standards indicated (base map modified from KER, 1992).

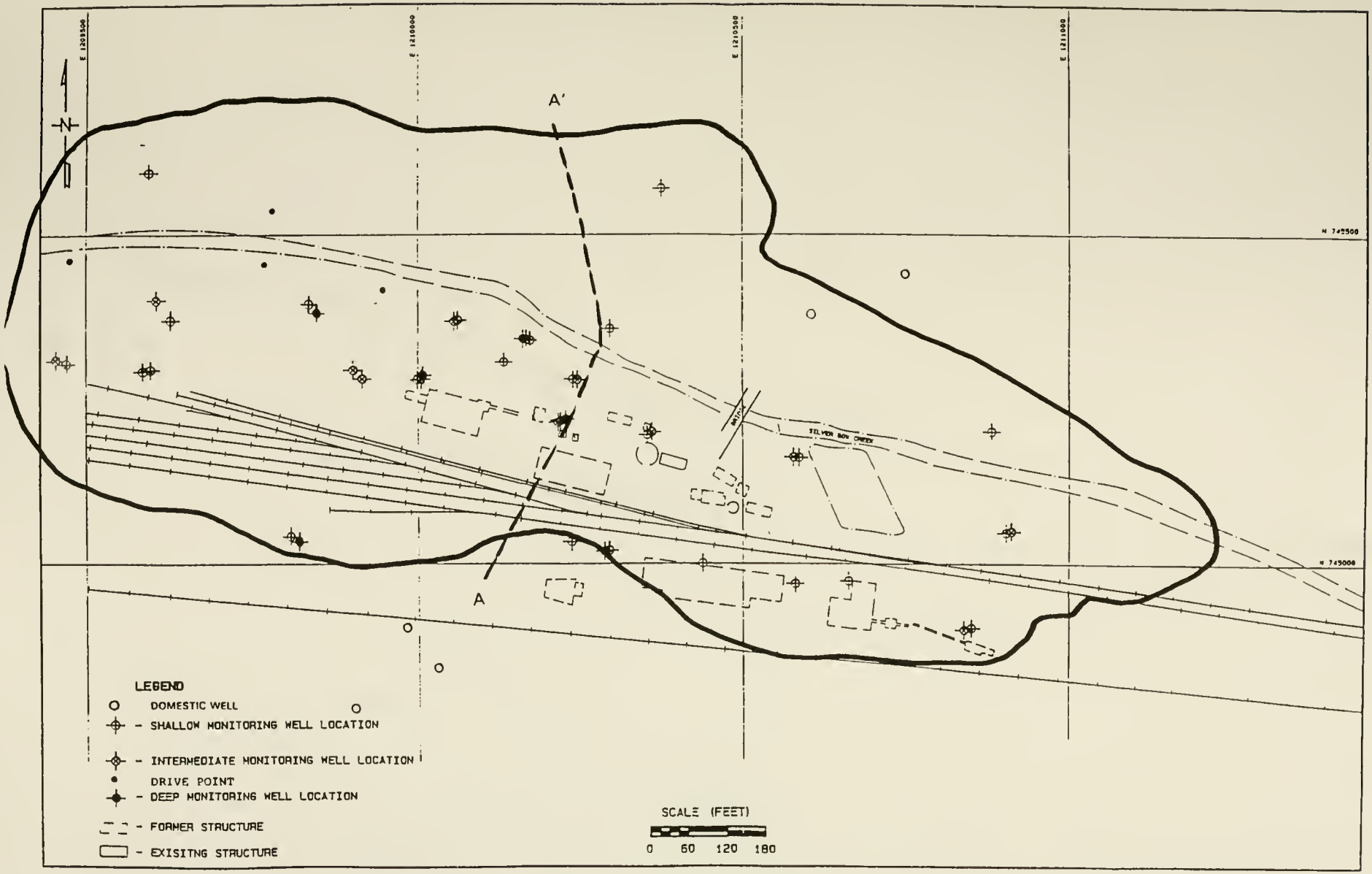

Figure 27: Median concentrations of one or more constituents in the shallow zone exceed drinking water standards. Cross section A-A' used for flux calculations (base map modified from KER, 1992).

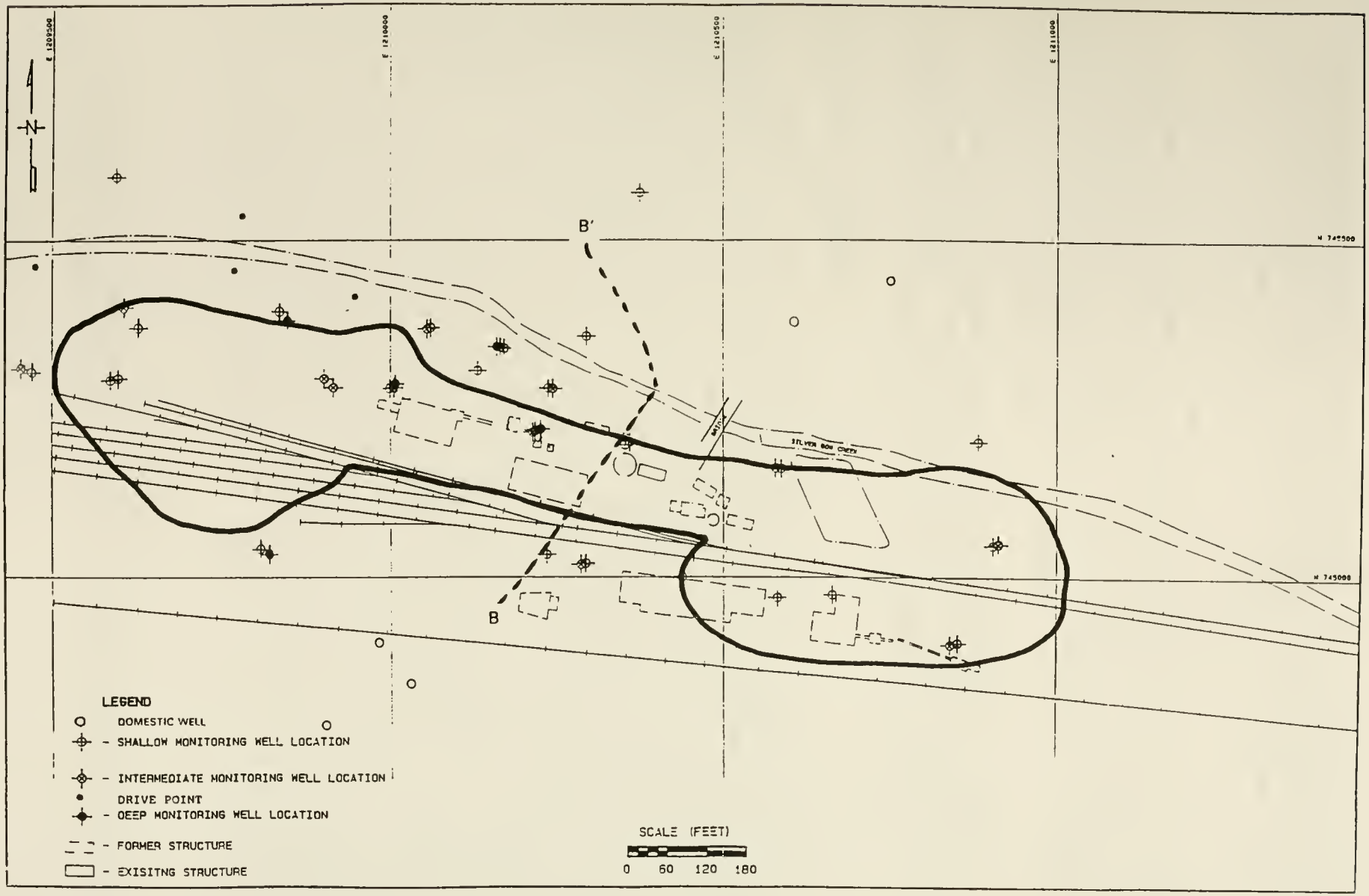

Figure 28: Median concentrations of one or more constituents in the intermediate zone exceed drinking water standards. Cross section B-B' used for flux calculations (base map modified from KER, 1992).

area exceeding drinking water standards by a saturated thickness that ranged from 30 to 40 ft (KER, 1992), and a porosity range of 0.20 to 0.45 (ESE, 1994). Wells finished in the underlying dense clay did not exceed standards for constituents assessed (Appendix A).

Wells 1, 7, 9, 11 and 21 contained one or more organic compounds that exceeded drinking water standards. However, constituents varied, and individual maps for the organic constituents were not produced. Instead, median values of reported PAH were plotted. A boundary of 5 ug/l was selected to indicate general organic contamination. This boundary is considered conservative as some specific compounds grouped as PAH's have standards of less than 1 ug/l.

Results of volume calculations are presented in Table 8. The total composite volume of contaminated groundwater ranges from 107 acft to 276 acft. The median value of 191 acft is used as representative of the volume of contaminated groundwater.

Flux of Groundwater

Figures 8 and 9 present the horizontal flow direction and gradients for the shallow and intermediate systems. KER (1992) estimated the hydraulic gradient for both systems to be about 0.005. The discharge per unit width of the shallow aquifer (approximately 12 ft of saturated thickness) is estimated by multiplying the gradient by the saturated thickness by the hydraulic conductivity of 9.4 ft/d (KER, 1992) to be 0.56 ft^2/d. The discharge per unit width of the intermediate zone (saturated thickness between 30 and 40 ft) is estimated by multiplying the gradient times the range of saturated thickness times the 9.4 ft/d which results in a discharge range of from 1.41 ft^2/d to 1.88 ft^2/d. These values were then applied to a 660 ft line following an equipotential line (Figure 8 and Figure 27) for the composite volume of the contaminated shallow zone and a similar 140 ft width (Figure 9 and Figure 28) of the composite intermediate volume. The discharge of water exceeding drinking water standards through these cross sections was calculated and is presented in Table 9. Results of calculations reveal an annual discharge of between 4.7 and 5.3 acft of contaminated groundwater flows from the site area down-gradient. It is assumed that the conditions at the Rocker Site are in steady state or pseudo-steady state, though soil removal efforts may have released additional contaminants (ESE, 1994). Within the limited data set, it generally appears areas of groundwater contamination are not expanding in size.

RECOVERABILITY

Groundwater underlying an area of approximately 1,900 ft by 600 ft, 26.2 acres, exceeds drinking water standards for one or

TABLE 8: Estimated Volumes of Contaminated Groundwater

Constituent	Shallow zone Volume (acft)	Intermediate Zone Range of Volume (acft)
Arsenic	30 - 68	17 - 51
Cadmium	17 - 38	
Copper	11 - 26	
Zinc	10 - 23	
Iron	45 - 101	30 - 90
Manganese	47 - 107	31 - 93
Sulfate	19 - 43	6 - 20
PAH	2 - 5	0.8 - 2
Composite Volume*	58 - 130	49 - 146

* combined areas with exceedence of one or more constituents

TABLE 9: Annual Discharge of Contaminated Groundwater in the Shallow and Intermediate Zone.

Zone	Discharge ft^2/d	Width ft	Discharge acft/y
Shallow	0.56	660	3.1
Intermediate	1.41-1.88	140	1.6 - 2.2
Total			4.7 - 5.3

more constituents. Soils and aquifer material contain arsenic, metals and organic hazardous materials related to the wood preservation process. Natural improvement in the groundwater quality at the site is not likely in the foreseeable future as flow rates are low and the source of contaminants in still present at the site (ESE, 1994). It is estimated between 10,000 and 15,000 cubic yards of arsenic contaminated soil are within the zone of saturation. ESE (1994) stated that prior to clean up operations in 1989 arsenic concentrations in monitoring wells appeared to be increasing. After the remediation effort they note that the soil clean up may have actually exacerbated controls on arsenic release as arsenic concentrations in some wells increased and others decreased. Generally, values of dissolved arsenic west of RH-5 and Rh-14 have increased. In contrast, some organic contaminant concentrations may be mitigated by natural microbial action, however, the length of time required to lower groundwater concentrations sufficiently to meet standards is unknown. Most likely, impacts will continue for hundreds of years unless the site is remediated.

SUMMARY AND CONCLUSIONS

The Rocker Timber Framing and Treating Plant milled and treated timbers used in the Butte underground mines, and treated poles and timbers for Montana Power Company. As a result of plant operations, soil and groundwater is contaminated with arsenic, metals and organic compounds. It is estimated that 191 acft of groundwater is contaminated with hazardous materials and exceeds drinking water standards at the site. In addition, groundwater is flowing through the site at a rate of 4.7 to 5.3 acft/yr and transporting hazardous substances to the west. The presence of hazardous substances in the aquifer substrate and probable continued natural recharge of the site will result in continued waste release and groundwater contamination for hundreds of years.

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*Keystone Environment Resources, Inc.

APPENDIX A

Groundwater Quality Data for Parameters Exceeding Drinking Water Standards, Rocker, Montana

APPENDIX A

(as reported)

WELL NUMBER	DATE	As (ug/L)		Cd (ug/L)		Cu (ug/L)		Fe (ug/l)		Pb (ug/L)		Mn (ug/l)		SO4 (mg/l)	Zn (ug/L)		PAH (ug/l)	WELL DEPTH (ft)	REFERENCE
AYERS	07/15/93	8.7		2	U	10		3	U	2	U	2		216	4			160	MBMG
DP-02	09/22/92	68.7	A																SBCGW92A
DP-03	09/22/92	1830	A																SBCGW92A
DP-04	09/29/92	16000	J																SBCGW92A
DP-05	09/30/92	131	J																SBCGW92A
DW-202	01/07/85	8.5		0.7	U	40	U	31	U	0.7	U			340	31			44	Stiller, 1985
DW-203	01/07/85	20		0.7	U	40	U	31	U	0.7	U			146	27	U		98	Stiller, 1985
DW-203	12/12/85	20		0		10		30		0				136	20				SBCGW85A
DW-204	01/07/85	12		0.7	U	65		31	U	0.7	U			56	55			58	Stiller, 1985
DW-206	01/07/85	33		0.7	U	40	U	31	U	0.7	U			198	69			30	Stiller, 1985
DW-207	01/07/85	21		0.7	U	40	U	35		0.7	U			271	33			44	Stiller, 1985
DW-208	01/07/85	15		0.7	U	48		31	U	0.8				129	600			50	Stiller, 1985
DW-210	01/07/85	13		0.7	U	40	U	31	U	0.7	U			106	73			55	Stiller, 1985
GS-01	01/15/85	6.3	U	0.6	U	40	U	31	U	1.1	U			100	27	U		14.6	Stiller, 1985
GS-01	02/85	5	U	1.1	U	27	U	28	U	2.8	U				14			14.6	CH2M Hill and Chen-N, 1989
GS-01	03/28/85	10		0		10	U	50	U	0				59	20				SBCGW85A
GS-01	06/85	3.8		1	U	14	U	20		3.7	U				11			14.6	CH2M Hill and Chen-N, 1989
GS-01	08/88	5	U	1	U	15.8	U	23.2	U	11 8		671			34 1			14 6	CH2M Hill and Chen-N, 1989
GS-01	08/19/88	87.8		89.5		252		127		75 4					212				SBCGW88A
PW-03	09/13/88	39																	Hydrometrics, 1989
PW-09	09/13/88	3																90	Hydrometrics, 1989
PW-12	09/13/88	3																82	Hydrometrics, 1989
PW-14	09/13/88	4																70	Hydrometrics, 1989
PW-20	09/13/88	5		5	U	25	U	400		4 1		15	U		90				Hydrometrics, 1989
RH-01	08/20/87	10		88		34000		130		26		20000		576	30000			13	Hydrometrics, 1987
RH-01	11/11/91	2	U	24.6		4240				103				300	6250			13	Keystone, 1992
RH-01	09/23/92	3	UA	37.1	A	10900	A	228	A	33.5	A				10700	A			SBCGW92A
RH-02	08/20/87	10		5	U	120		450		5	U	9000		296	3000			12	Hydrometrics, 1987
RH-02	11/12/91	2	U	3		15.7				1.1				134	1790			12	Keystone, 1992
RH-02	09/24/92	4.8	BJ	2	UA	10	BA	1800	A	1	UA				1810	J			SBCGW92A
RH-03	08/27/87	13		5	U	25	U	2000		5	U	1400		431	60			15	Hydrometrics, 1987
RH-03	11/12/91	2.1		5.6		2	U			1	U			554	78.6			15	Keystone, 1992
RH-03	09/24/92	3	UJ	3.7	BA	4	BA	163	A	1.1	BJ				109	J			SBCGW92A
RH-04	08/21/87	23		5	U	25	U	5900		5	U	14000		210	3100			15	Hydrometrics, 1987
RH-04	11/12/91	38 4		2	U	2	U			1	U			164	2440			15	Keystone, 1992
RH-04	09/24/92	53.9	J	2	UA	1	UA	9810	A	1.5	BA				3000	J			SBCGW92A
RH-05	08/20/87	490		78		4600		20000		9		72000		1370	54000			18	Hydrometrics, 1987
RH-05	06/03/88	700		90		7630		13700		4		43200		892	38500			18	Hydrometrics, 1989
RH-05	11/07/91	1680		42.8		3280				1	U			654	17800			18	Keystone, 1992
RH-05	09/28/92	2210	J	46.5	A	4340	A	7100	A	7.9	A				21500	A			SBCGW92A
RH-06	08/20/87	1600		17		25	U	25	U	5	U	130		617	20			39	Hydrometrics, 1987
RH-06	06/03/88	780		14		3		170		4	U	230		664	67			39	Hydrometrics, 1989
RH-06	11/11/91	875		2	U	2	U			1	U			666	9.9	UJ		39	Keystone, 1992
RH-06	09/28/92	719	J	2	UA	2.2	BA	8	UA	2	UA				5 1	BA			SBCGW92A
RH-06	09/28/92	658	J	2	UA	1	UA	8	UA	2	UA				5	UA			SBCGW92A
RH-07	08/21/87	43		5	U	25	U	100	U	5	U	15	U	109	1400			20	Hydrometrics, 1987
RH-07	11/08/91	47.2		2	U	15 4	UJ			1	U			117	1130	J	0.03	20	Keystone, 1992
RH-07	09/24/92	54.2	J	2	UA	9.2	BA	8	UA	1	UJ				1570	J			SBCGW92A
RH-08	08/20/87	14		5	U	25	U	1600		5	U	6000		155	65			40	Hydrometrics, 1987
RH-08	11/12/91	15.6		2.5		2	U	1710		1.2		5970		150	7.6	U		40	Keystone, 1992
RH-08	09/23/92	18	A	2	UA	2.2	BA	2130	A	1	UA				5	UA			SBCGW92A
RH-08	09/23/92	18.2	J	2	UA	1	UA	2180	A	1	UA				5	UJ			SBCGW92A
RH-09	08/20/87	21		5	U	33		100	U	5	U	220		482	120			16	Hydrometrics, 1987
RH-09	11/12/91	15 4		2	U	2	U			1	U			270	30.9	U		16	Keystone, 1992
RH-10	08/21/87	3100		30		240		720		5	U	4800		38	1100			17	Hydrometrics, 1987
RH-10	11/07/91	1210		6.2		50	U			1				126	1220	J	4.55	17	Keystone, 1992
RH-10	09/29/92	3000	A	8.5	A	408	A	1290	A	1	UJ				2180	A			SBCGW92A
RH-11	08/21/87	1900		17		25	U	3500		5	U	12000		285	4100			16	Hydrometrics, 1987
RH-11	11/06/91	7940		13.2		2	U			1				117	485	J	0.03	16	Keystone, 1992
RH-11	09/14/88	3530		5	U	25	U	4090		4.2		8680			2330			16	Hydrometrics, 1989

APPENDIX A

(as reported)

WELL NUMBER	DATE	As (ug/L)		Cd (ug/L)		Cu (ug/L)		Fe (ug/l)		Pb (ug/L)		Mn (ug/l)		SO4 (mg/l)	Zn (ug/L)		PAH (ug/l)	WELL DEPTH (ft)	REFERENCE
RH-11	09/29/92	4340	J	2.2	BA	1	UA	5710	A	1	U				1120	A			SBCGW92A
RH-11	09/29/92	3210	A	2.9	BA	1	UA	5910	A	1	BA				1110	A			SBCGW92A
RH-12	08/21/87	14		5	U	25	U	100		5	U	150		15	59			40	Hydrometrics, 1987
RH-12	09/14/88	11		50	U	25	U	100	U	2.9		15	U		520			40	Hydrometrics, 1989
RH-12	09/29/92	7.2	BA	2	UA	1	UA	8	UA	1	BA				5	UA			SBCGW92A
RH-13	09/13/88	6760		5	U	25	U	100	U	4.1		5920			52			17	Hydrometrics, 1989
RH-13	11/11/91	14100		36.8		2	U			1	UJ			263	564			17	Keystone, 1992
RH-13	09/28/92	6350	J	2	UA	1.4	BA	997	A	2	UA				724	A			SBCGW92A
RH-14	09/13/88	4940		5	U	25	U	2250		7.6		6410			96			39	Hydrometrics, 1989
RH-14	11/08/91	1300		2	U	15.6	UJ			1.2				19	38.1	UJ	5.43	39	Keystone, 1992
RH-14	09/28/92	6060	J	2	UA	1.3	BA	8	UA	2	UA				5	UA			SBCGW92A
RH-15	11/11/91	360	J	2.4		2	U			1	U			60.6	1340	J	5.03	17.5	Keystone, 1992
RH-15	09/24/92	955	J	2	UA	1	UA	4360	A	1	UA				2190	J			SBCGW92A
RH-16	11/07/91	15.6	U	2	U	4.6	U			1	U			15.8	6.5	UJ		46.5	Keystone, 1992
RH-16	09/24/92	10	J	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-17	11/06/91	46.2	J	2.2		229		30.2		1	U	666		52.4	134	J		14	Keystone, 1992
RH-17	09/28/92	97.6	J	2	UA	82.1	A	8	UA	2	UA				261	A			SBCGW92A
RH-18	11/07/91	35.1		2	U	4.3	U			4				16.2	7.8	UJ		42	Keystone, 1992
RH-18	09/28/92	14.1	J	2	UA	1	UA	8	UA	2	UA				5	UA			SBCGW92A
RH-19	11/06/91	388		2	U	2	U	34.9		1	U	1140		44.5	6	UJ	25.57	17	Keystone, 1992
RH-19	09/24/92	84	J	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-20	11/06/91	12.3		2	U	3.6	U	55.8		1	U	4.1		17.3	14.8	UJ	1.51	49	Keystone, 1992
RH-20	09/24/92	10.3	J	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-21	11/08/91	81.8		4	U	49.8	UJ			1	U			103	930	UJ	0.04	16	Keystone, 1992
RH-21	09/25/92	53.1	J	2.4	BA	112	A	111	A	1	UA				1240	J			SBCGW92A
RH-22	11/08/91	15.4		2	U	6.3	UJ			1	U			20.5	20.5	UJ		52	Keystone, 1992
RH-22	09/25/92	10.3	J	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-23	11/11/91	12.3	J	2	U	3.1				1	UJ			55.6	13.2			18	Keystone, 1992
RH-23	09/25/92	10.1	J	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-23	09/25/92	10.8	J	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-24	11/11/91	14.3		2	U	3.6				1	UJ			15.4	6	U	4	51	Keystone, 1992
RH-24	09/25/92	8.5	BJ	2	UA	1	UA	8	UA	2	UA				5	UA			SBCGW92A
RH-24	09/25/92	7.6	BJ	2	UA	1	UA	8	UA	1	UA				5	UJ			SBCGW92A
RH-25	11/11/91	27.9		2	U	3.7				1	UJ			39.2	18.8			17	Keystone, 1992
RH-25	09/28/92	37.7	J	2	UA	1	UA	3490	A	2	UA				15.1	BA			SBCGW92A
RH-26	11/11/91	313		2	U	4.1				1	UJ			250	1030			13.5	Keystone, 1992
RH-26	09/23/92	546	A	2	UA	1	UA	7880	A	1	UA				1140	A			SBCGW92A
RH-27	11/11/91	8.5												103			0.3	47	Keystone, 1992
RH-27	09/23/92	6.6	BA	2	UA	1	UA	8	UA	1	UA				5	UA			SBCGW92A
RH-28	11/11/91	47.9		2	U	2	U			1	UJ			212	713		0.06	16	Keystone, 1992
RH-28	09/25/92	88	BJ	2	UA	1	UA	13900	A	1	UA				983	J			SBCGW92A
RH-29	11/11/91	52.9		2	U	2	U			1	UJ			239	1600		0.03	14.5	Keystone, 1992
RH-29	09/23/92	68.8	A	2	UA	3.1	BA	14100	A	1.2	BA				2690	A			SBCGW92A
RH-30	11/11/91	8.3	J	2	U	4.3				2.2	J			82.2	9.7		0.49	50	Keystone, 1992
RH-30	09/23/92	9.1	BA	2	UA	1	UA	907	A	1	UA				5	UA			SBCGW92A
RH-31	11/08/91	36.5		2	U	7.6	UJ			1	U			16.5	26.8	UJ	0.03	55	Keystone, 1992
RH-31	09/29/92	13.2	A	2	UA	1	UA	8	UA	1	UJ				5	UA			SBCGW92A
RH-32	11/11/91	30.5		4.4		106				1.2	J			154	719		0.03	16.5	Keystone, 1992
RH-32	09/25/92	387	J	2	UA	25.5	A	2100	A	1	UJ				306	J			SBCGW92A
RH-33	11/07/91	24700		46.1		3.3	U			1	U			243	348	J		14	Keystone, 1992
RH-33	09/28/92	25700	J	2	UA	1	UA	3700	A	2	UA				729	A			SBCGW92A
RH-34	11/07/91	12.5		2	U	6.6	U			1	U			16.7	9.4	UJ		51	Keystone, 1992
RH-34	09/29/92	11	A	2	UA	1	UA	8	UA	1.2	BA				5	UA			SBCGW92A
RH-35	11/08/91	7.5	J	2	U	48.8	UJ			1	U			17.6	94.3	UJ		79.25	Keystone, 1992
RH-35	09/29/92	7.4	BA	2	UA	1	UA	8	UA	1	UA				5	UA			SBCGW92A
RH-36	11/08/91	2.2		2	U	33.9	UJ			1.1				6	78.1	UJ		84	Keystone, 1992
RH-36	09/30/92	3	UJ	2	UA	2	BA	8	UA	2	B				5.2	BA			SBCGW92A
RH-37	11/07/91	15.6	U	2	U	2	U			1				17.8	9	UJ	0.92	76.5	Keystone, 1992
RH-37	09/29/92	5.4	BA	2	UA	1	UA	8	UA	1.3	BA				5	UA			SBCGW92A
RH-38	09/28/92	51.5	J	2	UA	1	UA	8	UA	2	UA				5	UA			SBCGW92A

APPENDIX A

(as reported)

WELL NUMBER	DATE	As (ug/L)		Cd (ug/L)		Cu (ug/L)		Fe (ug/l)		Pb (ug/L)		Mn (ug/l)		SO4 (mg/l)		Zn (ug/L)		PAH (ug/l)	WELL DEPTH (ft)	REFERENCE
RH-40	09/29/92	19.6	J	2	UA	5.5	BA	8	UA	1	U					33.3	A			SBCGW92A
RH-41	09/22/92	11800	A	7.7	A	2.1	BA	32000	A	1.3	BA					85	A			SBCGW92A
RH-43	09/22/92	9.2	BA	2	UA	1	UA	8	UA	1	UA					5	UA			SBCGW92A
RH-43	05/05/94	7.8		2	U	2	U	3	U	2	U	2	U	200		2	U		113	MBMG
RH-43A	06/02/94	7.6		2	U	3.9		16		2	U	3		202		2	U		113	MBMG
RH-44	09/22/92	55.8	A	2	UA	1	UA	30000	A	1	UA					14.4	BA			SBCGW92A
RH-46	09/23/92	7.8	BA	2	UA	1	UA	8	UA	1	UA					6.7	BA			SBCGW92A
RH-46	09/23/92	8.5	BA	2	UA	2.5	BA	8	UA	1	UA					17.2	BA			SBCGW92A
RH-47	09/23/92	9.2	BA	91.6	A	8650	A	18100	A	11.3	A					34000	A			SBCGW92A
RH-48	09/23/92	3.8	BA	2	UA	1	UA	8	UA	1.2	BA					5	UA			SBCGW92A
TPWELL1	05/18/94	9.3		2	U	2	U	148		2	U	2	U	248		258			152	MBMG
TPWELL2	05/20/94	9.5		2	U	2	U	3		2	U	2	U	231		50.7			152	MBMG
TPUMP3	05/22/94	10.1		2	U	2	U	3	U	2	U	2	U	226		45.9			152	MBMG
TPUMP4	05/23/94	10.1		2	U	2	U	3	U	2	U	2	U	224		44.6			152	MBMG
TPUMP5	05/25/94	10.2		2	U	2	U	3	U	2	U	2	U	223		43.5			152	MBMG
TPUMP6	05/25/94	10.5		2	U	2	U	3		2	U	2	U	225		43.8			152	MBMG

Notes:

U, UA, OR UJ = BELOW DETECTION LIMIT

J = estimated due to QC problems

B = value less than contract but greater than instrument detection limit

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MBMG: FINAL REPORT RESULTS FOR THE TOWN PUMP AQUIFER TEST, MONTANA BUREAU OF MINES AND GEOLOGY, SEPTEMBER 16, 1994.

APPENDIX B

Groundwater Quality Data for Parameters Exceeding Drinking Water Standards, Rocker, Montana
(adjusted for detection limits)

APPENDIX B
ROCKER WATER QUALITY DATA
(adjustad for detection limits)

WELL NUMBER	DATE	As		Cd		Cu		Fe		Pb		Mn		SO4		Zn		PAH		WELL DEPTH	REFERENCE
		(ug/L)	n	(ug/L)	n	(ug/L)	n	(ug/l)	n	(ug/L)	n	(ug/l)	n	(mg/l)	n	(ug/L)	n	(ug/l)	n	(ft)	
AYERS	07/15/93	8.7		1	U	10		1.5	U	1	U	1		216		4				160	MBMG
DP-02	09/22/92	68.7	A																		SBCGW92A
DP-03	09/22/92	1830	A																		SBCGW92A
DP-04	09/29/92	16000	J																		SBCGW92A
DP-05	09/30/92	131	J																		SBCGW92A
DW-202	01/07/85	8.5		0.35	U	20	U	15.5	U	0.35	U			340		31				44	Stiller, 1985
DW-203	01/07/85	20		0.35	U	20	U	15.5	U	0.35	U			146		13.5	U			98	Stiller, 1985
DW-203	12/12/85	20				10		30						136		20					SBCGW85A
	MEDIAN	20	2	0.35	1	15	2	22.75	2	0.35	1		0	141	2	16.75	2				
DW-204	01/07/85	12		0.35	U	65		15.5	U	0.35	U			56		55				58	Stiller, 1985
DW-206	01/07/85	33		0.35	U	20	U	15.5	U	0.35	U			198		69				30	Stiller, 1985
DW-207	01/07/85	21		0.35	U	20	U	35		0.35	U			271		33				44	Stiller, 1985
DW-208	01/07/85	15		0.35	U	48		15.5	U	0.8				129		600				50	Stiller, 1985
DW-210	01/07/85	13		0.35	U	20	U	15.5	U	0.35	U			106		73				55	Stiller, 1985
GS-01	01/15/85	3.15	U	0.3	U	20	U	15.5	U	0.55	U			100		13.5	U			14.6	Stiller, 1985
GS-01	02/85	2.5	U	0.55	U	13.5	U	14	U	1.4	U					14				14.6	CH2M Hill and Chen-N, 1989
GS-01	03/28/85	10				5	U	25	U					59		20					SBCGW85A
GS-01	06/85	3.8		0.5	U	6	U	20		1.85	U					11				14.6	CH2M Hill and Chen-N, 1989
GS-01	08/88	2.5	U	0.5	U	7.9	U	11.6	U	11.8		671				34.1				14.6	CH2M Hill and Chen-N, 1989
GS-01	08/19/88	87.8		89.5		252		127		75.4						212					SBCGW88A
	MEDIAN	3.475	6	0.5	5	10.7	6	17.75	6	1.85	5	671	1	79.5	2	17	6				
PW-03	09/13/88	39																			Hydrometrics, 1989
PW-09	09/13/88	3																		90	Hydrometrics, 1989
PW-12	09/13/88	3																		82	Hydrometrics, 1989
PW-14	09/13/88	4																		70	Hydrometrics, 1989
PW-20	09/13/88	5		2.5	U	12.5	U	400		4.1		7	U			90					Hydrometrics, 1989
RH-01	08/20/87	10		88		34000		130		26		20000		576		30000				13	Hydrometrics, 1987
RH-01	11/11/91	1	U	24.6		4240				103				300		6250				13	Keystone, 1992
RH-01	09/23/92	1.5	UA	37.1	A	10900	A	228	A	33.5	A					10700	A				SBCGW92A
	MEDIAN	1.5	3	37.1	3	10900	3	179	2	33.5	3	20000	1	438	2	10700	3				
RH-02	08/20/87	10		2.5	U	120		450		2.5	U	9000		296		3000				12	Hydrometrics, 1987
RH-02	11/12/91	1	U	3		15.7				1.1				134		1790				12	Keystone, 1992
RH-02	09/24/92	4.8	BJ	1	UA	10	BA	1800	A	0.5	UA					1810	J				SBCGW92A
	MEDIAN	4.8	3	2.5	3	15.7	3	1125	2	1.1	3	9000	1	215	2	1810	3				
RH-03	08/27/87	13		2.5	U	12.5	U	2000		2.5	U	1400		431		60				15	Hydrometrics, 1987
RH-03	11/12/91	2.1		5.6		1	U			0.5	U			554		78.6				15	Keystone, 1992
RH-03	09/24/92	1.5	UJ	3.7	BA	4	BA	163	A	1.1	BJ					109	J				SBCGW92A
	MEDIAN	2.1	3	3.7	3	4	3	1081.5	2	1.1	3	1400	1	492.5	2	78.6	3				
RH-04	08/21/87	23		2.5	U	12.5	U	5900		2.5	U	14000		210		3100				15	Hydrometrics, 1987
RH-04	11/12/91	38.4		1	U	1	U			0.5	U			164		2440				15	Keystone, 1992
RH-04	09/24/92	53.9	J	1	UA	0.5	UA	9810	A	1.5	BA					3000	J				SBCGW92A
	MEDIAN	38.4	3	1	3	1	3	7855	2	1.5	3	14000	1	187	2	3000	3				
RH-05	08/20/87	490		78		4600		20000		9		72000		1370		54000				18	Hydrometrics, 1987
RH-05	06/03/88	700		90		7630		13700		4		43200		892		38500				18	Hydrometrics, 1989
RH-05	11/07/91	1680		42.8		3280				0.5	U			654		17800				18	Keystone, 1992
RH-05	09/28/92	2210	J	46.5	A	4340	A	7100	A	7.9	A					21500	A				SBCGW92A
	MEDIAN	1190	4	62.25	4	4470	4	13700	3	5.95	4	57600	2	892	3	30000	4				
RH-06	08/20/87	1600		17		12.5	U	12.5	U	2.5	U	130		617		20				39	Hydrometrics, 1987
RH-06	06/03/88	780		14		3		170		2	U	230		664		67				39	Hydrometrics, 1989
RH-06	11/11/91	875		1	U	1	U			0.5	U			666		4.95	UJ			39	Keystone, 1992
RH-06	09/28/92	719	J	1	UA	2.2	BA	4	UA	1	UA					5.1	BA				SBCGW92A
RH-06	09/28/92	658	J	1	UA	0.5	UA	4	UA	1	UA					2.5	UA				SBCGW92A
	MEDIAN	780	5	1	5	2.2	5	8.25	4	1	5	180	2	664	3	5.1	5				

APPENDIX B
ROCKER WATER QUALITY DATA
(adjusted for detection limits)

WELL NUMBER	DATE	As		Cd		Cu		Fe		Pb		Mn		SO4		Zn		PAH		WELL DEPTH	REFERENCE
		(ug/L)	n	(ug/L)	n	(ug/L)	n	(ug/l)	n	(ug/L)	n	(ug/l)	n	(mg/l)	n	(ug/L)	n	(ug/l)	n	(ft)	
RH-07	08/21/87	43		2.5	U	12.5	U	50	U	2.5	U	7	U	109		1400				20	Hydrometrics, 1987
RH-07	11/08/91	47.2		1	U	7.7	UJ			0.5	U			117		1130	J	0.03		20	Keystone, 1992
RH-07	09/24/92	54.2	J	1	UA	9.2	BA	4	UA	0.5	UJ					1570	J				SBCGW92A
	MEDIAN	47.2	3	1	3	9.2	3	27	2	0.5	3	7	1	113	2	1400	3	0.03	1		
RH-08	08/20/87	14		2.5	U	12.5	U	1600		2.5	U	6000		155		65				40	Hydrometrics 1987
RH-08	11/12/91	15.6		2.5		1	U	1710		1.2		5970		150		3.8	U			40	Keystone, 1992
RH-08	09/23/92	18	A	1	UA	2.2	BA	2130	A	0.5	UA					2.5	UA				SBCGW92A
RH-08	09/23/92	18.2	J	1	UA	0.5	UA	2180	A	0.5	UA					2.5	UJ				SBCGW92A
	MEDIAN	16.8	4	1.75	4	1.6	4	1920	4	0.85	4	5985	2	152.5	2	3.15	4				
RH-09	08/20/87	21		2.5	U	33		50	U	2.5	U	220		482		120				16	Hydrometrics, 1987
RH-09	11/12/91	15.4		1	U	1	U			0.5	U			270		15.45	U			16	Keystone, 1992
	MEDIAN	18.2	2	1.75	2	17	2	50	1	1.5	2	220	1	376	2	67.725	2				
RH-10	08/21/87	3100		30		240		720		2.5	U	4800		38		1100				17	Hydrometrics, 1987
RH-10	11/07/91	1210		6.2		25	U			0.5				126		1220	J	4.55		17	Keystone, 1992
RH-10	09/29/92	3000	A	8.5	A	408	A	1290	A	0.5	UJ					2180	A				SBCGW92A
	MEDIAN	3000	3	8.5	3	240	3	1005	2	0.5	3	4800	1	82	2	1220	3	4.55	1		
RH-11	08/21/87	1900		17		12.5	U	3500		2.5	U	12000		285		4100				16	Hydrometrics, 1987
RH-11	09/14/88	3530		2.5	U	12.5	U	4090		4.2		8680				2330				16	Hydrometrics, 1989
RH-11	11/06/91	7940		13.2		1	U			1				117		485	J	0.03		16	Keystone, 1992
RH-11	09/29/92	4340	J	2.2	BA	0.5	UA	5710	A	0.5	U					1120	A				SBCGW92A
RH-11	09/29/92	3210	A	2.9	BA	0.5	UA	5910	A	1	BA					1110	A				SBCGW92A
	MEDIAN	3530	5	2.9	5	1	5	4900	4	1	5	10340	2	201	2	1120	5	0.03	1		
RH-12	08/21/87	14		2.5	U	12.5	U	100		2.5	U	150		15		59				40	Hydrometrics, 1987
RH-12	09/14/88	11		25	U	12.5	U	50	U	2.9		7	U			520				40	Hydrometrics, 1989
RH-12	09/29/92	7.2	BA	1	UA	0.5	UA	4	UA	1	BA					2.5	UA				SBCGW92A
	MEDIAN	11	3	2.5	3	12.5	3	50	3	2.5	3	78.5	2	15	1	59	3				
RH-13	09/13/88	6760		2.5	U	12.5	U	50	U	4.1		5920				52				17	Hydrometrics, 1989
RH-13	11/11/91	14100		36.8		1	U			0.5	UJ			263		564				17	Keystone, 1992
RH-13	09/28/92	6350	J	1	UA	1.4	BA	997	A	1	UA					724	A				SBCGW92A
	MEDIAN	6760	3	2.5	3	1.4	3	523.5	2	1	3	5920	1	263	1	564	3				
RH-14	09/13/88	4940		2.5	U	12.5	U	2250		7.6		6410				96				39	Hydrometrics, 1989
RH-14	11/08/91	1300		1	U	7.8	UJ			1.2				19		19.05	UJ	5.43		39	Keystone, 1992
RH-14	09/28/92	6060	J	1	UA	1.3	BA	4	UA	1	UA					2.5	UA				SBCGW92A
	MEDIAN	4940	3	1	3	7.8	3	1127	2	1.2	3	6410	1	19	1	19.05	3	5.43	1		
RH-15	11/11/91	360	J	2.4		1	U			0.5	U			60.6		1340	J	5.03		17.5	Keystone, 1992
RH-15	09/24/92	955	J	1	UA	0.5	UA	4360	A	0.5	UA					2190	J				SBCGW92A
	MEDIAN	657.5	2	1.7	2	0.75	2	4360	1	0.5	2		0	60.6	1	1765	2	5.03	1		
RH-16	11/07/91	7.8	U	1	U	2.3	U			0.5	U			15.8		3.25	UJ			46.5	Keystone, 1992
RH-16	09/24/92	10	J	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A
	MEDIAN	8.9	2	1	2	1.4	2	4	1	0.5	1		0	15.8	1	2.875	2				
RH-17	11/06/91	46.2	J	2.2		229		30.2		.5	U	666		52.4		134	J			14	Keystone, 1992
RH-17	09/28/92	97.6	J	1	UA	82.1	A	4	UA	1	UA					261	A				SBCGW92A
	MEDIAN	71.9	2	1.6	2	155.55	2	17.1	2	0.75	2	666	1	52.4	1	197.5	2				
RH-18	11/07/91	35.1		1	U	2.15	U			4				16.2		3.9	UJ			42	Keystone, 1992
RH-18	09/28/92	14.1	J	1	UA	0.5	UA	4	UA	1	UA					2.5	UA				SBCGW92A
	MEDIAN	24.6	2	1	2	1.325	2	4	1	2.5	2		0	16.2	1	3.2	2				
RH-19	11/06/91	388		1	U	1	U	34.9		0.5	U	1140		44.5		3	UJ	25.57		17	Keystone, 1992
RH-19	09/24/92	84	J	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A
	MEDIAN	236	2	1	2	0.75	2	19.45	2	0.5	2	1140	1	44.5	1	2.75	2	25.57	1		
RH-20	11/06/91	12.3		1	U	1.8	U	55.8		0.5	U	4.1		17.3		7.4	UJ	1.51		49	Keystone, 1992
RH-20	09/24/92	10.3	J	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A
	MEDIAN	11.3	2	1	2	1.15	2	29.9	2	0.5	2	4.1	1	17.3	1	4.95	2	1.51	1		
RH-21	11/08/91	81.8		2	U	24.9	UJ			0.5	U			103		465	UJ	0.04		16	Keystone, 1992
RH-21	09/25/92	53.1	J	2.4	BA	112	A	111	A	0.5	UA					1240	J				SBCGW92A
	MEDIAN	67.45	2	2.2	2	68.45	2	111	1	0.5	2		0	103	1	852.5	2	0.04	1		
RH-22	11/08/91	15.4		1	U	3.85	UJ			0.5	U			20.5		10.25	UJ			52	Keystone, 1992
RH-22	09/25/92	10.3	J	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A
	MEDIAN	12.85	2	1	2	2.075	2	4	1	0.5	2		0	20.5	1	6.375	2				
RH-23	11/11/91	12.3	J	1	U	3.1				0.5	UJ			55.6		13.2				18	Keystone, 1992
RH-23	09/25/92	10.1	J	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A
RH-23	09/25/92	10.8	J	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A

APPENDIX B
ROCKER WATER QUALITY DATA
(adjusted for detection limits)

WELL NUMBER	DATE	As		Cd		Cu		Fe		Pb		Mn		SO4		Zn		PAH		WELL DEPTH	REFERENCE
		(ug/L)	n	(ug/L)	n	(ug/L)	n	(ug/l)	n	(ug/L)	n	(ug/l)	n	(mg/l)	n	(ug/L)	n	(ug/l)	n	(ft)	
	MEDIAN	10.8	3	1	3	0.5	3	4	2	0.5	3		0	55.6	1	2.5	3				
RH-24	11/11/91	14.3		1	U	3.6				0.5	UJ			15.4		3	U	4		51	Keystone 1992
RH-24	09/25/92	8.5	BJ	1	UA	0.5	UA	4	UA	1	UA					2.5	UA				SBCGW92A
RH-24	09/25/92	7.6	BJ	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UJ				SBCGW92A
	MEDIAN	8.5	3	1	3	0.5	3	4	2	0.5	3		0	15.4	1	2.5	3	4	1		
RH-25	11/11/91	27.8		1	U	3.7				0.5	UJ			39.2		18.8				17	Keystone 1992
RH-25	09/28/92	37.7	J	1	UA	0.5	UA	3490	A	1	UA					15.1	BA				SBCGW92A
	MEDIAN	32.8	2	1	2	2.1	2	3490	1	0.75	2		0	39.2	1	16.95	2				
RH-26	11/11/91	313		1	U	4.1				0.5	UJ			250		1030				13.5	Keystone 1992
RH-26	09/23/92	546	A	1	UA	0.5	UA	7880	A	0.5	UA					1140	A				SBCGW92A
	MEDIAN	429.5	2	1	1	2.3	2	7880	1	0.5	2		0	250	1	1085	2				
RH-27	11/11/91	8.5												103				0.3		47	Keystone, 1992
RH-27	09/23/92	6.6	BA	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UA				SBCGW92A
	MEDIAN	7.55	2	1	1	0.5	1	4	1	0.5	1		0	103	1	2.5	1	0.3	1		
RH-28	11/11/91	47.9		1	U	1	U			0.5	UJ			212		713		0.06		16	Keystone 1992
RH-28	09/25/92	88	BJ	1	UA	0.5	UA	13900	A	0.5	UA					983	J				SBCGW92A
	MEDIAN	67.95	2	1	2	0.75	2	13900	1	0.5	2		0	212	1	848	2	0.06	1		
RH-29	11/11/91	52.9		1	U	1	U			0.5	UJ			239		1600		0.03		14.5	Keystone, 1992
RH-29	09/23/92	68.8	A	1	UA	3.1	BA	14100	A	1.2	BA					2690	A				SBCGW92A
	MEDIAN	60.85	2	1	2	2.05	2	14100	1	0.85	2		0	239	1	2145	2	0.03	1		
RH-30	11/11/91	8.3	J	1	U	4.3				2.2	J			82.2		9.7		0.49		50	Keystone, 1992
RH-30	09/23/92	9.1	BA	1	UA	0.5	UA	907	A	0.5	UA					2.5	UA				SBCGW92A
	MEDIAN	8.7	2	1	2	2.4	2	907	1	1.35	2		0	82.2	1	6.1	2	0.49	1		
RH-31	11/08/91	36.5		1	U	3.8	UJ			0.5	U			16.5		13.4	UJ	0.03		55	Keystone, 1992
RH-31	09/29/92	13.2	A	1	UA	0.5	UA	4	UA	0.5	UJ					2.5	UA				SBCGW92A
	MEDIAN	24.85	2	1	2	2.15	2	4	1	0.5	2		0	16.5	1	7.95	2	0.03	1		
RH-32	11/11/91	30.5		4.4		106				1.2	J			154		719		0.03		16.5	Keystone, 1992
RH-32	09/25/92	387	J	1	UA	25.5	A	2100	A	0.5	UJ					306	J				SBCGW92A
	MEDIAN	208.75	2	2.7	2	65.75	2	2100	1	0.85	2		0	154	1	512.5	2	0.03	1		
RH-33	11/07/91	24700		46.1		1.65	U			0.5	U			243		348	J			14	Keystone, 1992
RH-33	09/28/92	25700	J	1	UA	0.5	UA	3700	A	1	UA					729	A				SBCGW92A
	MEDIAN	25200	2	23.55	2	1.075	2	3700	1	0.75	2		0	243	1	538.5	2				
RH-34	11/07/91	12.5		1	U	3.3	U			0.5	U			16.7		4.7	UJ			51	Keystone, 1992
RH-34	09/29/92	11	A	1	UA	0.5	UA	4	UA	1.2	BA					2.5	UA				SBCGW92A
	MEDIAN	11.75	2	1	2	1.9	2	4	1	0.85	2		0	16.7	1	3.6	2				
RH-35	11/08/91	7.5	J	1	U	24.4	UJ			0.5	U			17.6		47.15	UJ			79.25	Keystone, 1992
RH-35	09/29/92	7.4	BA	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UA				SBCGW92A
	MEDIAN	7.45	2	1	2	12.45	2	4	1	0.5	2		0	17.6	1	24.825	2				
RH-36	11/08/91	2.2		1	U	16.95	UJ			1.1				6		39.55	UJ			84	Keystone, 1992
RH-36	09/30/92	1.5	UJ	1	UA	2	BA	4	UA	2	B					5.2	BA				SBCGW92A
	MEDIAN	1.85	2	1	2	9.475	2	4	1	1.55	2		0	6	1	22.375	2				
RH-37	11/07/91	7.8	U	1	U	1	U			1				17.8		3	UJ	0.92		76.5	Keystone, 1992
RH-37	09/29/92	5.4	BA	1	UA	0.5	UA	4	UA	1.3	BA					2.5	UA				SBCGW92A
	MEDIAN	6.6	2	1	2	0.75	2	4	1	1.15	2		0	17.8	1	2.75	2	0.92	1		
RH-38	09/28/92	51.5	J	1	UA	0.5	UA	4	UA	1	UA					2.5	UA				SBCGW92A
RH-40	09/29/92	19.6	J	1	UA	5.5	BA	4	UA	0.5	U					33.3	A				SBCGW92A
RH-41	09/22/92	11800	A	7.7	A	2.1	BA	32000	A	1.3	BA					85	A				SBCGW92A
RH-43	09/22/92	8.2	BA	1	UA	0.5	UA	4	UA	0.5	UA					2.5	UA				SBCGW92A
RH-43	05/05/94	7.8		1	U	1	U	1.5	U	1	U	1	U	200		1	U			113	MBMG
RH-43A	06/02/94	7.6		1	U	3.9		16		1	U	3		202		1	U			113	MBMG
	MEDIAN	7.8	3	1	3	1	3	4	3	1	3	2	2	201	2	1	3				
RH-44	09/22/92	55.8	A	1	UA	0.5	UA	30000	A	0.5	UA					14.4	BA				SBCGW92A
RH-46	09/23/92	7.8	BA	1	UA	0.5	UA	4	UA	0.5	UA					6.7	BA				SBCGW92A
RH-46	09/23/92	8.5	BA	1	UA	2.5	BA	4	UA	0.5	UA					17.2	BA				SBCGW92A
	MEDIAN	8.15	2	1	2	1.5	2	4	2	0.5	2		0		0	11.95	2				
RH-47	09/23/92	9.2	BA	91.6	A	8650	A	18100	A	11.3	A					34000	A				SBCGW92A

APPENDIX B
ROCKER WATER QUALITY DATA
(adjusted for detection limits)

WELL NUMBER	DATE	As		Cd		Cu		Fe		Pb		Mn		SO4		Zn		PAH		WELL DEPTH	REFERENCE
		(ug/L)	n	(ug/L)	n	(ug/L)	n	(ug/l)	n	(ug/L)	n	(ug/l)	n	(mg/l)	n	(ug/L)	n	(ug/l)	n	(ft)	
RH-48	09/23/92	3.8	BA	1	UA	0.5	UA	4	UA	1.2	BA					2.5	UA				SBCGW92A
TPWELL1	05/18/94	9.3		1	U	1	U	148		1	U	1	U	248		258				152	MBMG
TPWELL2	05/20/94	9.5		1	U	1	U	3		1	U	1	U	231		50.7				152	MBMG
TPUMP3	05/22/94	10.1		1	U	1	U	1.5	U	1	U	1	U	226		45.9				152	MBMG
TPUMP4	05/23/94	10.1		1	U	1	U	1.5	U	1	U	1	U	224		44.6				152	MBMG
TPUMP5	05/25/94	10.2		1	U	1	U	1.5	U	1	U	1	U	223		43.5				152	MBMG
TPUMP6	05/25/94	10.5		1	U	1	U	3		1	U	1	U	225		43.8				152	MBMG
	MEDIAN	10.1	6	1	6	1	6	2.25	6	1	6	1	6	225.5	6	45.25	6				

NOTES.

U, UA, OR UJ = BELOW DETECTION LIMIT, VALUE REPLACED BY 1/2 DETECTION LIMIT
J = estimated due to QC problems
B = value less than contract but greater than instrument detection limit
n= number of samples

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MBMG: FINAL REPORT RESULTS FOR THE TOWN PUMP AQUIFER TEST, MONTANA BUREAU OF MINES AND GEOLOGY, SEPTEMBER 16, 1994

APPENDIX C

Groundwater Quality Parameters
Median Values
Rocker, Montana

APPENDIX C
ROCKER WATER QUALITY DATA
MEDIAN VALUES

WELL NUMBER	As		Cd		Cu		Fe		Pb		Mn		SO4		Zn		PAH	
	(ug/L)	n	(ug/L)	n	(ug/L)	n	(ug/l)	n	(ug/L)	n	(ug/l)	n	(mg/l)	n	(ug/L)	n	(ug/l)	n
AYERS	8.7	1	1	1	10	1	1.5	1	1	1	1	1	216	1	4	1		
DP-02	68.7	1		0		0		0		0		0		0		0		
DP-03	1830	1		0		0		0		0		0		0		0		
DP-04	16000	1		0		0		0		0		0		0		0		
DP-05	131	1		0		0		0		0		0		0		0		
DW-202	8.5	1	0.4	1	20	1	16	1	0.4	1		0	340	1	31	1		
DW-203	20	2	0.4	1	15	2	23	2	0.4	1		0	141	2	17	2		
DW-204	12	1	0.4	1	65	1	16	1	0.4	1		0	56	1	55	1		
DW-206	33	1	0.4	1	20	1	16	1	0.4	1		0	198	1	69	1		
DW-207	21	1	0.4	1	20	1	35	1	0.4	1		0	271	1	33	1		
DW-208	15	1	0.4	1	48	1	16	1	0.8	1		0	129	1	600	1		
DW-210	13	1	0.4	1	20	1	16	1	0.4	1		0	106	1	73	1		
GS-01	3	6	1	5	11	6	18	6	1.9	5	671	1	80	2	17	6		
PW-03	39	1		0		0		0		0		0		0		0		
PW-09	3	1		0		0		0		0		0		0		0		
PW-12	3	1		0		0		0		0		0		0		0		
PW-14	4	1		0		0		0		0		0		0		0		
PW-20	5	1	2.5	1	13	1	400	1	4.1	1	7	1		0	90	1		
RH-01	2	3	37	3	10900	3	179	2	34	3	20000	1	438	2	10700	3		
RH-02	5	3	3	3	16	3	1125	2	1.1	3	9000	1	215	2	1810	3		
RH-03	2	3	4	3	4	3	1082	2	1.1	3	1400	1	493	2	79	3		
RH-04	38	3	1	3	1	3	7855	2	1.5	3	14000	1	187	2	3000	3		
RH-05	1190	4	62	4	4470	4	13700	3	6.0	4	57600	2	892	3	30000	4		
RH-06	780	5	1	5	2	5	8	4	1	5	180	2	664	3	5	5		
RH-07	47	3	1	3	9	3	27	2	0.5	3	7	1	113	2	1400	3	0.03	1
RH-08	17	4	2	4	2	4	1920	4	0.9	4	5985	2	153	2	3	4		
RH-09	18	2	2	2	17	2	50	1	1.5	2	220	1	376	2	68	2		
RH-10	3000	3	9	3	240	3	1005	2	0.5	3	4800	1	82	2	1220	3	4.55	1
RH-11	3530	5	3	5	1	5	4900	4	1	5	10340	2	201	2	1120	5	0.03	1
RH-12	11	3	3	3	13	3	50	3	2.5	3	79	2	15	1	59	3		
RH-13	6760	3	3	3	1	3	524	2	1	3	5920	1	263	1	564	3		
RH-14	4940	3	1	3	8	3	1127	2	1.2	3	6410	1	19	1	19	3	5.43	1
RH-15	658	2	2	2	0.8	2	4360	1	0.5	2		0	60.6	1	1765	2	5.03	1
RH-16	9	2	1	2	1.4	2	4	1	0.5	1		0	15.8	1	3	2		
RH-17	71.9	2	2	2	155.6	2	17	2	0.8	2	666	1	52.4	1	198	2		
RH-18	24.6	2	1	2	1.3	2	4	1	2.5	2		0	16.2	1	3	2		
RH-19	236	2	1	2	0.8	2	19	2	0.5	2	1140	1	44.5	1	3	2	25.6	1
RH-20	11.3	2	1	2	1.2	2	30	2	0.5	2	4.1	1	17.3	1	5	2	1.51	1
RH-21	67.5	2	2	2	68	2	111	1	0.5	2		0	103	1	853	2	0.04	1
RH-22	12.9	2	1	2	2.1	2	4	1	0.5	2		0	20.5	1	6	2		
RH-23	10.8	3	1	3	0.5	3	4	2	0.5	3		0	55.6	1	3	3		
RH-24	8.5	3	1	3	0.5	3	4	2	0.5	3		0	15.4	1	3	3	4	1
RH-25	32.8	2	1	2	2.1	2	3490	1	0.8	2		0	39.2	1	17.0	2		
RH-26	430	2	1	1	2.3	2	7880	1	0.5	2		0	250	1	1085	2		
RH-27	7.6	2	1	1	0.5	1	4	1	0.5	1		0	103	1	3	1	0.3	1
RH-28	68	2	1	2	0.8	2	13900	1	0.5	2		0	212	1	848	2	0.06	1
RH-29	60.9	2	1	2	2.1	2	14100	1	0.9	2		0	239	1	2145	2	0.03	1
RH-30	8.7	2	1	2	2.4	2	907	1	1.4	2		0	82.2	1	6	2	0.49	1
RH-31	24.9	2	1	2	2.2	2	4	1	0.5	2		0	16.5	1	8	2	0.03	1
RH-32	209	2	3	2	66	2	2100	1	0.9	2		0	154	1	513	2	0.03	1
RH-33	25200	2	24	2	1.1	2	3700	1	0.8	2		0	243	1	539	2		
RH-34	12	2	1	2	1.9	2	4	1	0.9	2		0	16.7	1	4	2		
RH-35	7.5	2	1	2	12	2	4	1	0.5	2		0	17.6	1	25	2		
RH-36	2	2	1	2	9	2	4	1	1.6	2		0	6	1	22	2		

APPENDIX C
ROCKER WATER QUALITY DATA
MEDIAN VALUES

WELL NUMBER	As		Cd		Cu		Fe		Pb		Mn		SO4		Zn		PAH	
	(ug/L)	n	(ug/L)	n	(ug/L)	n	(ug/l)	n	(ug/L)	n	(ug/l)	n	(mg/l)	n	(ug/L)	n	(ug/l)	n
RH-37	6.6	2	1	2	0.8	2	4	1	1.2	2		0	17.8	1	3	2	0.92	1
RH-38	51.5	1	1	1	0.5	1	4	1	1	1		0		0	3	1		
RH-40	19.6	1	1	1	5.5	1	4	1	0.5	1		0		0	33	1		
RH-41	11800	1	7.7	1	2.1	1	32000	1	1.3	1		0		0	85	1		
RH-43	7.8	3	1	3	1	3	4	3	1	3	2	2	201	2	1	3		
RH-44	55.8	1	1	1	0.5	1	30000	1	0.5	1		0		0	14.4	1		
RH-46	8.2	2	1	2	1.5	2	4	2	0.5	2		0		0	12.0	2		
RH-47	9.2	1	91.6	1	8650	1	18100	1	11.3	1		0		0	34000	1		
RH-48	3.8	1	1	1	0.5	1	4	1	1.2	1		0		0	3	1		
TPUMP	10.1	6	1	6	1	6	2.3	6	1	6	1	6	225.6	6	45.3	6		

n= number of samples